Chapter 4. Lakes and Reservoirs

4.1 Introduction

Since the initiation of the rotating basin approach in 1998, the state's significant publicly owned reservoirs are monitored over a five-year cycle instead of the previous seven- to eight-year cycle. During this two-year reporting period, 19 reservoirs in the Salt and Licking river basins and 25 lakes and reservoirs in the Cumberland, Tennessee, and Mississippi river basins were monitored for trophic state and use support (Figures 4-1 through 4-14 in the back of this chapter). Most of the natural lakes in the state are shallow floodplain lakes and are found in the Mississippi River Basin.

Designated uses in lakes consist of Warm Water Aquatic Habitat (WAH) (sometimes in conjunction with Cold Water Aquatic Habitat (CAH) in lakes with a two-story fishery) and Primary and Secondary Contact Recreation (PCR and SCR). Many of the reservoirs also have a Domestic Water Supply (DWS) use.

4.2 Methods

Sampling was conducted seasonally three times during the growing season, typically in late April to early May, July, and late September to early October. Composite nutrient and chlorophyll *a* samples were collected from the photic zone (one percent of light penetration), and dissolved oxygen, temperature, pH, and specific conductivity measurements were obtained from profiles of the water column in the deepest part of the lake. Samples were taken in the area immediately upstream of the dam and at other locations on the main lake and major tributary embayments depending on the size and configuration of each reservoir. Trophic data also were provided by the U.S. Army Corps of Engineers (2001) and White et al. (1999) on lakes in the Cumberland basin management unit. TVA (2000, 2001) collected fecal coliform bacteria on 10 occasions from mid-June to mid-July in both 2000 and 2001 from 18 recreational locations in the Kentucky portion of Kentucky Lake.

4.3 Assessment of Trophic State and Use Support

Trophic status was assessed in lakes by using the Carlson Trophic State Index (TSI) for chlorophyll *a*. This method is convenient because it allows lakes to be ranked numerically according to increasing eutrophy, and it also provides for a distinction between oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic lakes. The growing season (April – October) averaged TSI value was used to rank each lake. Areas of lakes that exhibited trophic gradients or embayment differences often were analyzed separately. Use support in lakes was determined by criteria listed in Table 4-1.

Table 4-1. Criteria for Lake Use Support Classification

Category	Warm Water Aquatic Habitat	Secondary Contact Water Recreation	Domestic Water Supply
Not Supporting:	(At least two of the following criteria)	(At least one of the following criteria)	(At least one of the following criteria)
	Fish kills caused by poor water quality	Widespread excess macrophyte/macro-scopic algal growth	Chronic taste and odor complaints caused by algae
	Severe hypolimnetic oxygen depletion	Chronic nuisance algal blooms	Chronic treatment problems caused by poor water quality
	Dissolved oxygen average less than 4 mg/l in the epilimnion		Exceeds drinking water MCL
Partially Supporting: (At least one of the following criteria)	Dissolved oxygen average less than 5 mg/l in the epilimnion	Localized or seasonally excessive macrophyte/macroscopic algal growth	Occasional taste and odor complaints caused by algae
	Severe hypolimnetic oxygen depletion	Occasional nuisance algal blooms	Occasional treatment problems caused by poor water quality
	Other specific cause (i.e. low pH)	High suspended sediment concentrations during the recreation season	
Fully Supporting:	None of the above	None of the above	None of the above

4.4 Results

4.4.1 Statewide

Tables 4-2, 4-3, and 4-4 present statewide summary statistics of use support and causes and sources of impairments of reservoirs and lakes in the state. The water quality assessment of lakes included more than 90 percent of the publicly owned lake acreage of Kentucky. Eighty-three of 123 lakes (67 percent) fully supported their uses, 33 (27 percent) partially supported uses, and 7 (6 percent) did not support one or more uses. On an acreage basis, more than 55 percent (120,372 acres) of the 217,597 assessed acres fully supported uses, 43 percent (93,311 acres) partially supported uses, and 2 percent (6,156 acres) did not support one or more uses (Table 4-2).

Mercury in fish tissue was the most frequent cause of uses in lakes not being fully supported (Table 4-3). Nutrients and organic enrichment/low dissolved oxygen were the second most frequent causes of use impairment, with agricultural runoff, land disposal, and septic tanks the principal sources of the nutrients (Table 4-4). A fish consumption advisory for PCBs affected one lake of considerable size (Green River Lake), resulting in a high percentage of lake acres impacted by priority organics (Table 4-3). Naturally shallow lake basins (habitat alterations and siltation when combined), which allow the proliferation of nuisance aquatic weeds that impair secondary contact recreation, accounted for the fifth highest cause of use nonsupport. Other natural conditions such as manganese releases from anoxic hypolimnetic water and nutrients in runoff from relatively undisturbed watersheds affected domestic water supply and secondary contact uses, respectively. Suspended solids from surface mining activities, which has decreased in severity as a source from previous years, impaired the secondary contact recreation use in only one eastern Kentucky reservoir.

4.4.2 Salt/Licking and Cumberland Basin Management Units

In the Salt/Licking unit, eleven reservoirs were eutrophic and eight were mesotrophic (Tables 4-5, 4-6, and 4-7). Eight of these reservoirs fully supported uses, nine partially supported uses, and two did not support uses (Figures 4-1 through 4-14 at the end of this chapter).

Table 4-2. Lake Use Support Summary, Acres (Number)

Use	Assessed	Fully Supporting	Partially Supporting	Not Supporting
Overall Support	217,597 (107)	120,372 (67)	93,311 (33)	3,914 (7)
Aquatic Life Support	217,597	207,646	6,176	3,775
Fish Consumption	203,513	115,688	87,825	0
Primary Contact Recreation	4,389	4,170	219	0
Secondary Contact Recreation	6,919	2,940	3,979	0
Drinking Water Supply	201,810	200,099	1,572	139

Table 4-3. Causes of Use Impairment in Lakes

Name	Acres Affected	Percent
Priority Organics	8,210	7
Metals	87,825	77
Nutrients	7,676	7
pH	219	<1
Siltation	1,368	1
Organic enrichment/Low DO	6,035	5
Other habitat alterations	413	<1
Taste and odor	811	1
Suspended solids	1,810	2
Algal Growth/Chlorophyll a	139	<1

Table 4-4. Sources of Impairment in Lakes

Name	Acres Affected	Percent
Industrial Point Sources	8,210	24
Municipal Point Sources	4,309	12
Agriculture	8,975	26
Resource Extraction	3,259	9
Land Disposal	4,196	12
Contaminated Sediments	18	<1
Internal nutrient cycling (primarily lakes)	3,366	10
Natural Sources	2,416	7

Table 4-5. Lakes in the Salt/Licking and Cumberland Basin Management Units Fully Supporting All Uses

Lake	Acres	County	Trophic State	Uses
Salt River Basin				
Beaver Lake	158	Anderson	Mesotrophic	WAH,PCR,SCR
Reformatory Lake	54	Oldham	Eutrophic	WAH,PCR,SCR
Sympson Lake	184	Nelson	Eutrophic	WAH,PCR,SCR,DWS
Long Run Lake	27	Jefferson	Mesotrophic	WAH,PCR,SCR
Willisburg Lake	126	Washington	Eutrophic	WAH,PCR,SCR
Licking River Basin				
A.J.Jolly (Campbell County) Lake	204	Campbell	Eutrophic	WAH,PCR,SCR
Lake Carnico	114	Nicholas	Mesotrophic	WAH,PCR,SCR
Williamstown Lake	300	Grant	Mesotrophic	WAH,PCR,SCR,DWS
Upper Cumberland River Basin				
Cannon Creek Lake	243	Bell	Oligotrophic	WAH,CAH,PCR,SCR,DWS
Chenoa Lake	37	Bell	Mesotrophic	WAH,PCR,SCR
Dale Hollow Reservoir	4300	Clinton	Oligotrophic	WAH,PCR,SCR
Lake Linville	273	Rockcastle	Eutrophic	WAH,PCR,SCR,DWS
Laurel Creek Lake	88	McCreary	Eutrophic	WAH,PCR,SCR,DWS
Laurel River Reservoir	6060	Whitley	Oligotrophic	WAH,CAH,PCR,SCR,DWS
Martins Fork Reservoir	334	Harlan	Oligotrophic	WAH,PCR,SCR
Tyner Lake	87	Jackson	Mesotrophic	WAH,CAH,PCR,SCR,DWS
Lower Cumberland River Basin				
Energy Lake	370	Trigg	Eutrophic	WAH,PCR,SCR
Honker Lake	190	Lyon	Hypereutrophic	WAH,PCR,SCR
Lake Barkley	45600	Lyon	Eutrophic	WAH,PCR,SCR,DWS
Lake Blythe	89	Christian	Mesotrophic	WAH,PCR,SCR,DWS
Lake Morris	170	Christian	Eutrophic	WAH,PCR,SCR,DWS
Tennessee River Basin				
Kentucky Lake	48100	Calloway	Eutrophic	WAH,PCR,SCR,DWS
Ohio River Basin				
Turner Lake	61	Ballard	Eutrophic	WAH,PCR,SCR
Buck Lake	19	Ballard	Eutrophic	WAH,PCR,SCR
Fish Lake	27	Ballard	Eutrophic	WAH,PCR,SCR
Long Pond	56	Ballard	Eutrophic	WAH,PCR,SCR
Mitchell Lake	58	Ballard	Eutrophic	WAH,PCR,SCR
Happy Hollow Lake	20	Ballard	Hypereutrophic	WAH,PCR,SCR
Mississippi River Basin				
Flat Lake	38	Ballard	Eutrophic	WAH,PCR,SCR
Burnt Pond	10	Ballard	Eutrophic	WAH,PCR,SCR
Beaverdam Lake	50	Ballard	Hypereutrophic	WAH,PCR,SCR
Shelby Lake	24	Ballard	Eutrophic	WAH,PCR,SCR
Arrowhead Lake	37	Ballard	Eutrophic	WAH,PCR,SCR

Table 4-6. Lakes in the Salt/Licking and Cumberland Basin Management Units Partially Supporting One or More Uses

Lake	Acres	County	Trophic State	Use Impaired[a]	Causes	Sources
Salt River Basin						
Marion Co Sportsman Lake	21	Marion	Mesotrophic	WAH	Nutrients	Other
McNeely Lake	51	Jefferson	Eutrophic	WAH FC	Nutrients Mercury	Internal Nutrient Cycling, Source Unknown
Lake Shelby	17	Shelby	Eutrophic	WAH	Nutrients	Agriculture, Internal Nutrient Cycling
Taylorsville Lake	3050	Spencer	Eutrophic	WAH	Nutrients	Agriculture
Licking River Basin						
Cave Run Lake	8270	Rowan	Mesotrophic	FC	Mercury	Source Unknown
Doe Run Lake	51	Kenton	Eutrophic	WAH	Nutrients	Source Unknown
Greenbriar Lake	66	Montgomery	Mesotrophic	WAH	Low DO	Agriculture, Natural Sources
Kincaid Lake	183	Pendleton	Mesotrophic	WAH	Nutrients	Source Unknown
Sand Lick Creek Lake	74	Fleming	Eutrophic	WAH	Low DO, Other Habitat Alterations	Agriculture, Internal Nutrient Cycling
Upper Cumberland River Basin						
Cranks Creek Lake	219	Harlan	Oligotrophic	WAH	pH	Abandoned Mine lands
Lake Cumberland	50250	Russell	Oligotrophic	FC	Mercury	Source Unknown
Wood Creek Lake	672	Laurel	Oligotrophic	DWS	Taste and Odor	Onsite Wastewater Systems (Septic tanks)
Ohio River Basin						
Metropolis Lake	36	McCracken	Eutrophic	FC	Mercury, PCBs	Source Unknown

[a] WAH = Warm Water Aquatic Life; FC = Fish Consumption; DWS = Domestic Water Supply

Of the 25 lakes and reservoirs monitored in the Cumberland unit, 19 fully supported uses, 3 partially supported uses, and 3 did not support uses (Tables 4-5, 4-6, and 4-7). The most common causes were mercury in fish tissue and nutrients (phosphorus, nitrogen, and carbon) that eventually result in depleted or lowered dissolved oxygen in the water column. In the Upper Cumberland River Basin, 2 reservoirs were eutrophic, 3 were mesotrophic, and 7 were oligotrophic. Of the other 13 lakes and reservoirs monitored in the Lower Cumberland, Tennessee, and Mississippi river basins, 2 were hyper-eutrophic, 10 were eutrophic, and 1 was mesotrophic.

Table 4-7. Lakes in the Salt/Licking and Cumberland Basin Management Units Not Supporting One Or More Uses

Lake	Acres	County	Trophic State	Use Impaired[a]	Causes	Sources
Salt River Basin						
Guist Creek Lake	317	Shelby	Eutrophic	WAH	Nutrients, Low Dissolved Oxygen	Agriculture, Natural Sources, Land Disposal, Onsite Wastewater Systems (Septic tanks)
Lake Jericho	137	Henry	Eutrophic	WAH	Nutrients	Agriculture
Upper Cumberland River Basin						
Corbin City Reservoir	139	Laurel	Mesotrophic	WAH	Nutrients, Algae Growth, Organic Enrichment/ Low Dissolved Oxygen	Agriculture, Internal Nutrient Cycling, Municipal Point Sources
				DWS	Taste and Odor	
Lower Cumberland River Basin						
Hematite Lake	90	Trigg	Eutrophic	WAH	Low Dissolved Oxygen	Natural Sources
Mississippi River Basin						
Swan Pond	193	Ballard	Eutrophic	WAH	Low Dissolved Oxygen	Agriculture, Natural Sources

[A] WAH = Warm Water Aquatic Habitat; DWS = domestic water supply

Figure 4-1. Reservoirs Monitored in the Licking River Basin

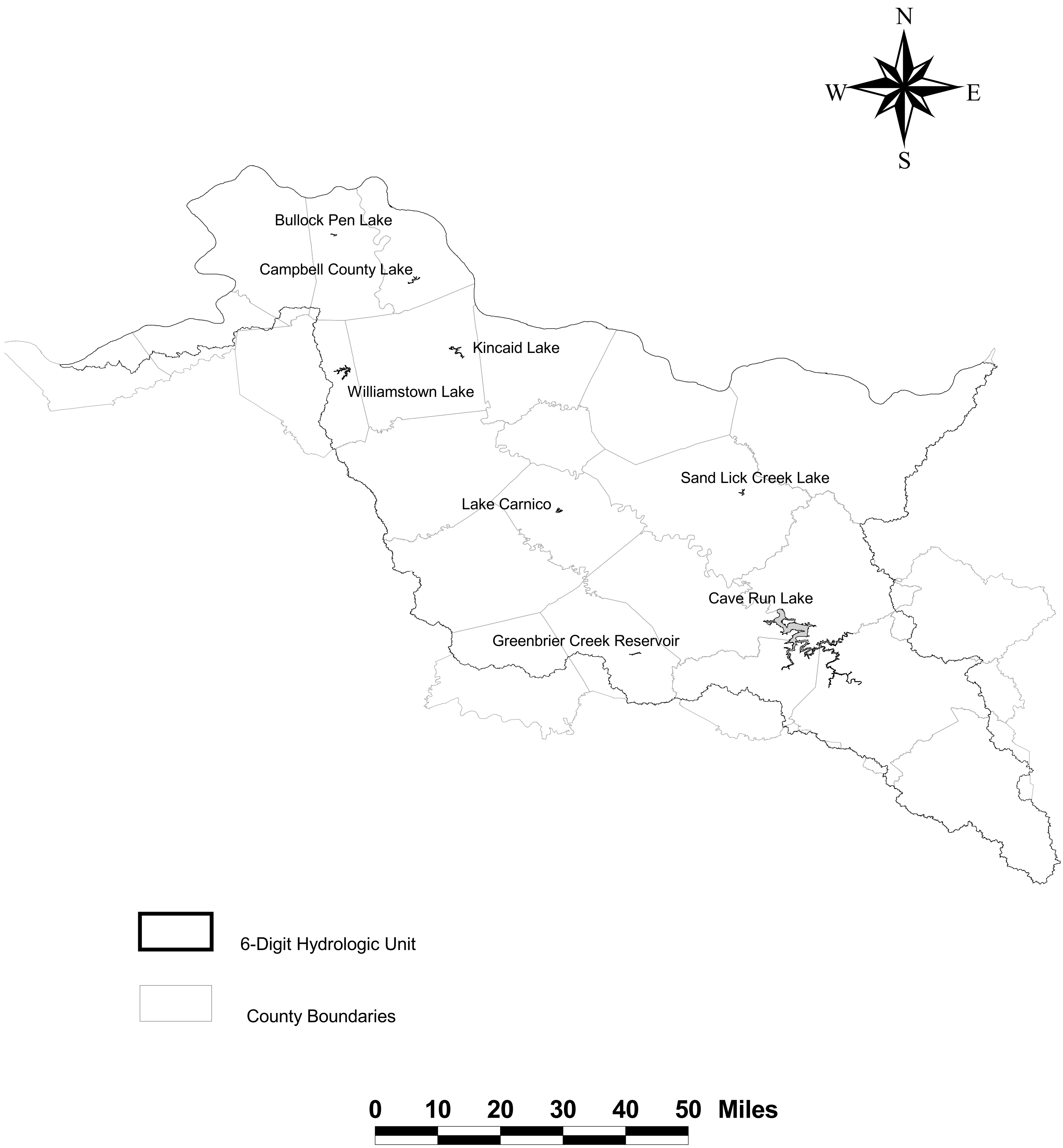


Figure 4-2. Monitoring Sites on Cave Run Lake

Figure 4-3. Monitoring Sites on Small Reservoirs in the Licking River Basin

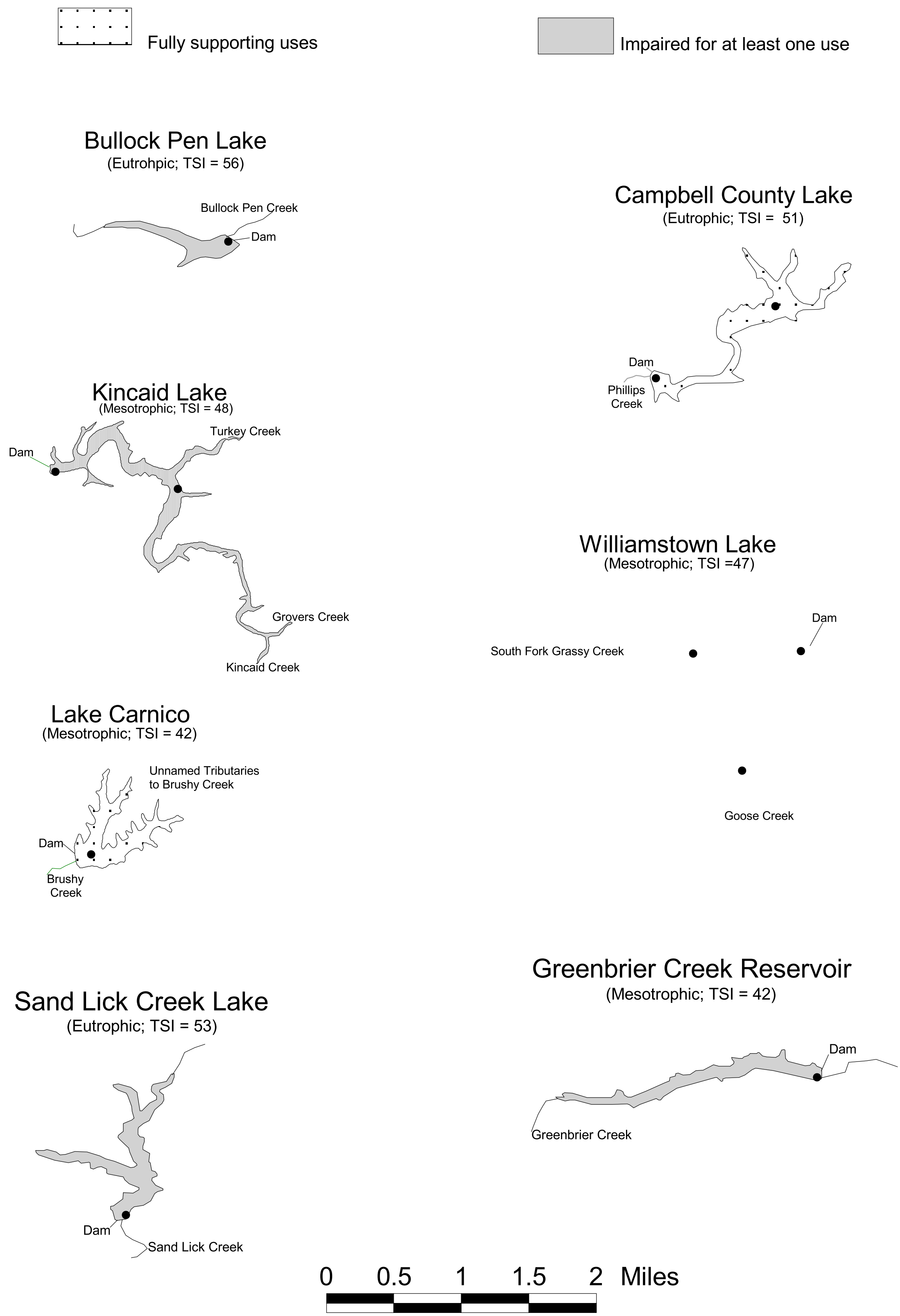


Figure 4-4. Reservoirs Monitored in the Salt River Basin

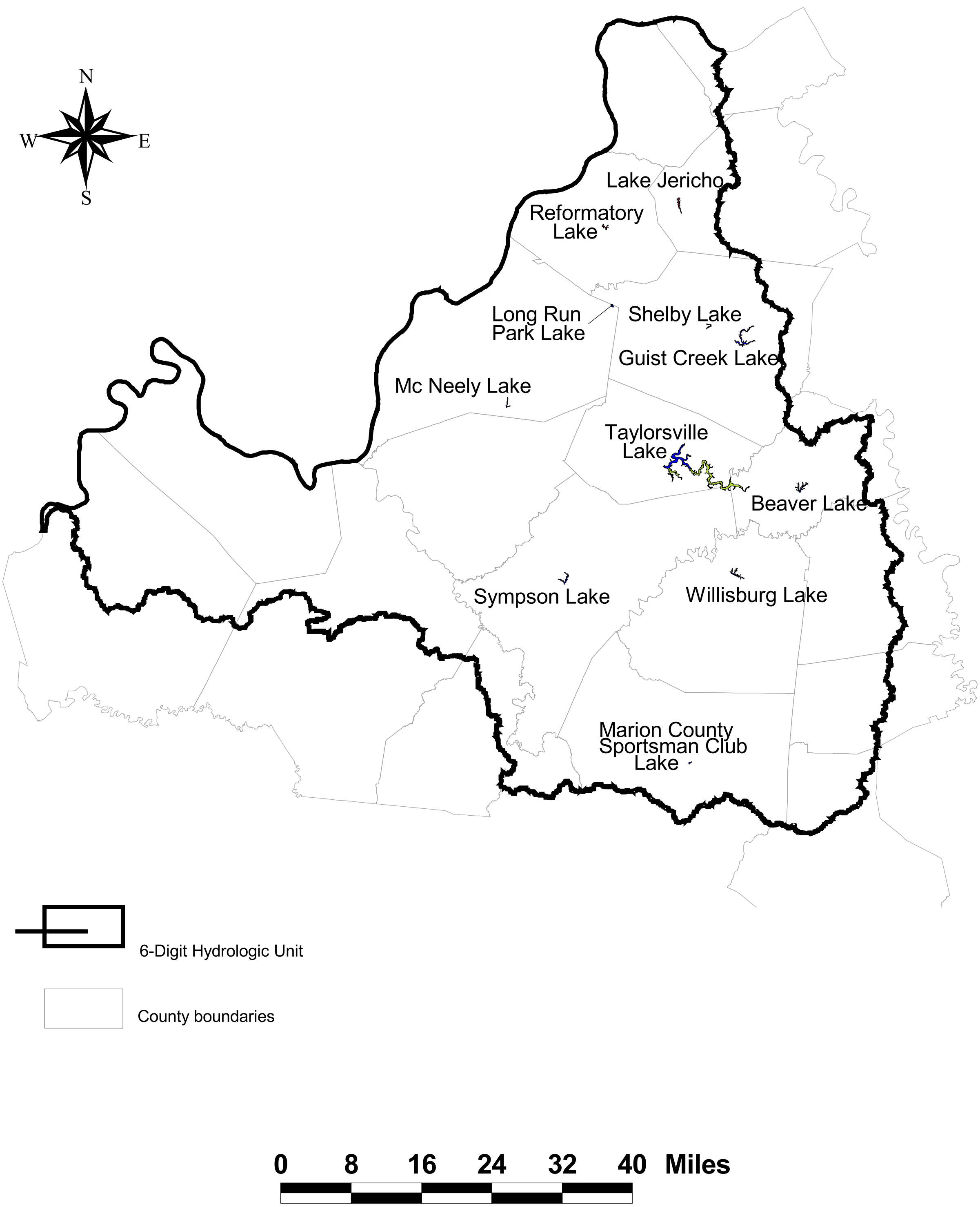


Figure 4-5. Monitoring Sites on Taylorsville Lake and Guist Creek Lake

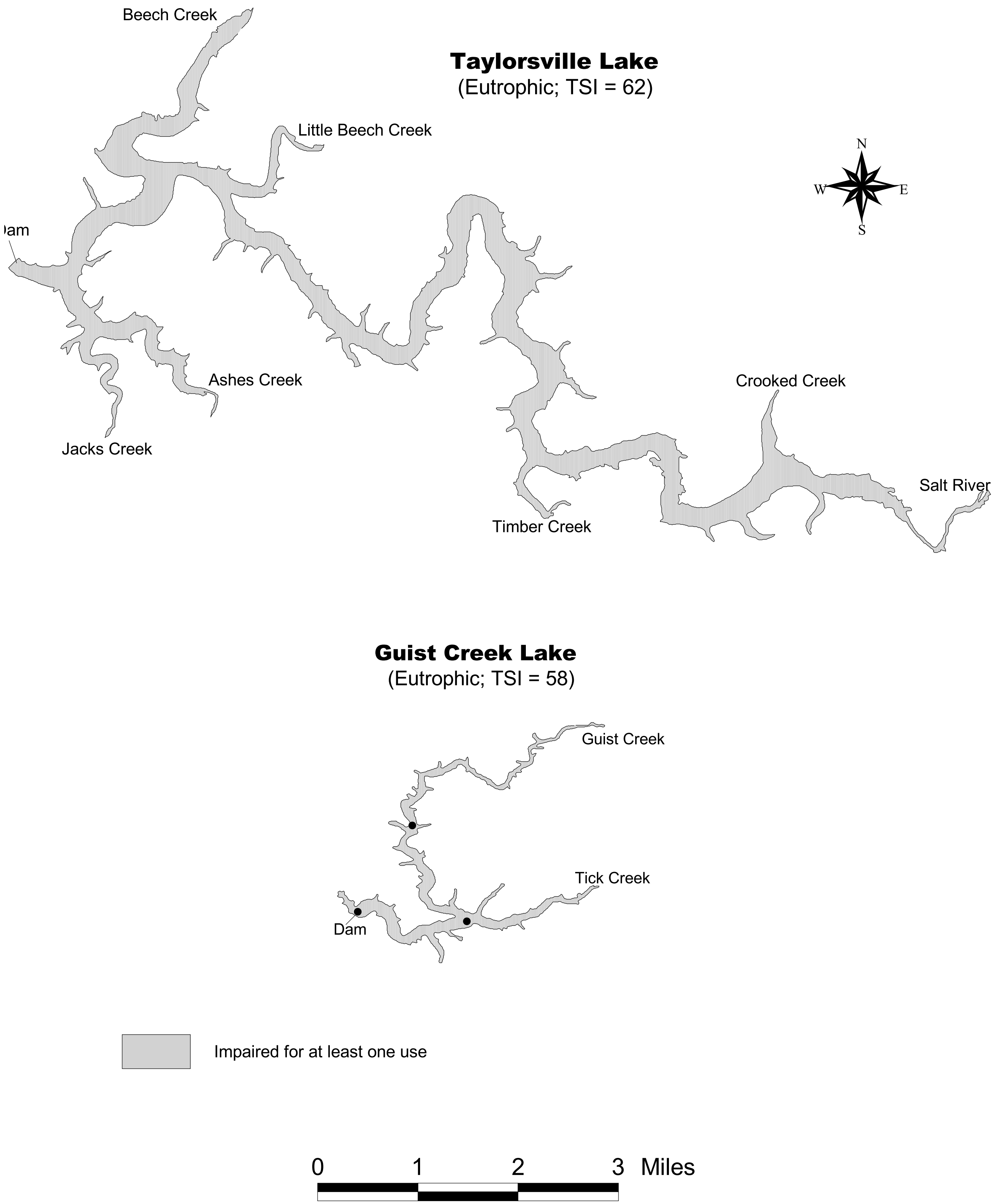


Figure 4-6. Monitoring Sites on Small Reservoirs in the Salt River Basin

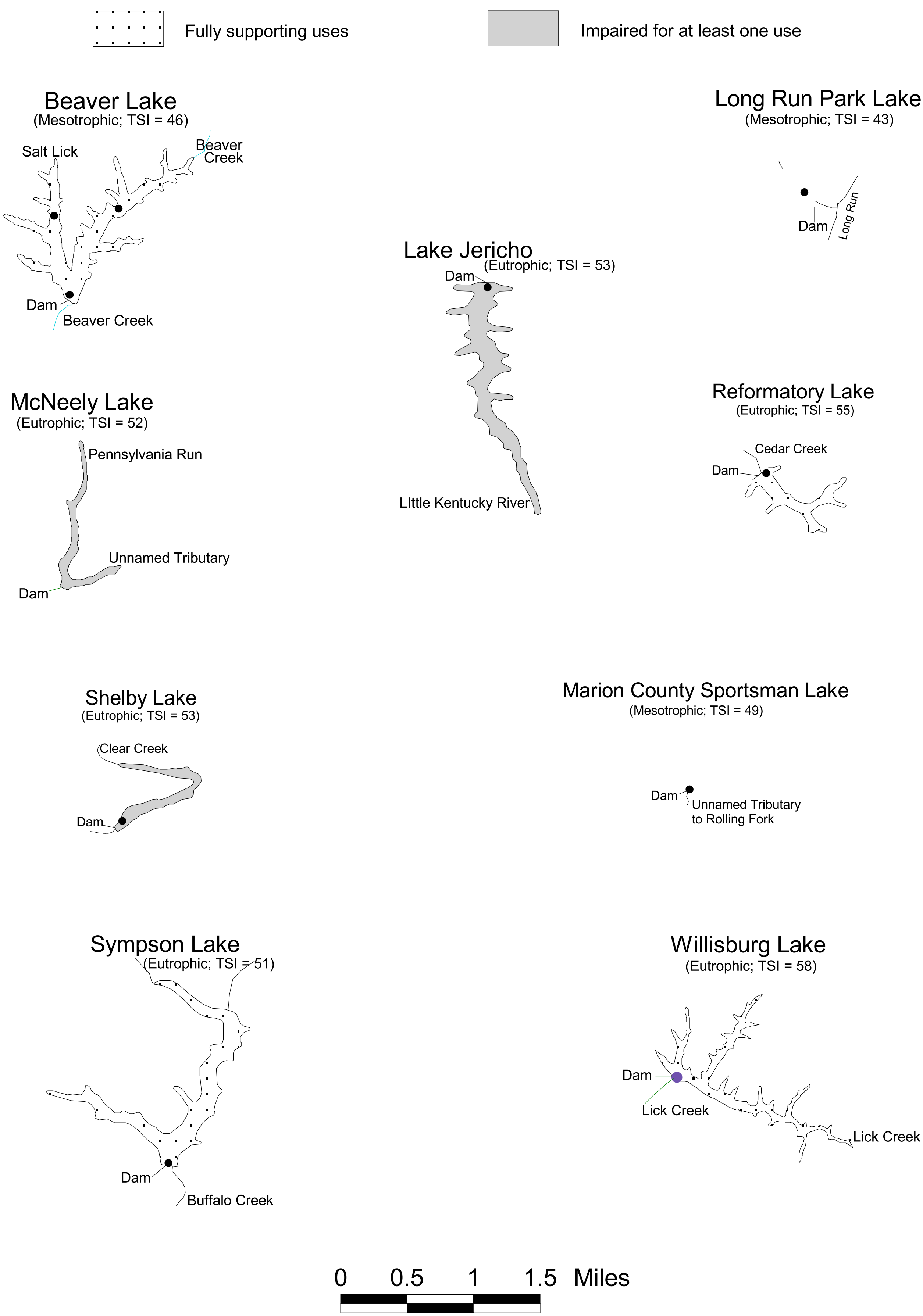


Figure 4-7. Reservoirs Monitored in the Upper Cumberland River Basin

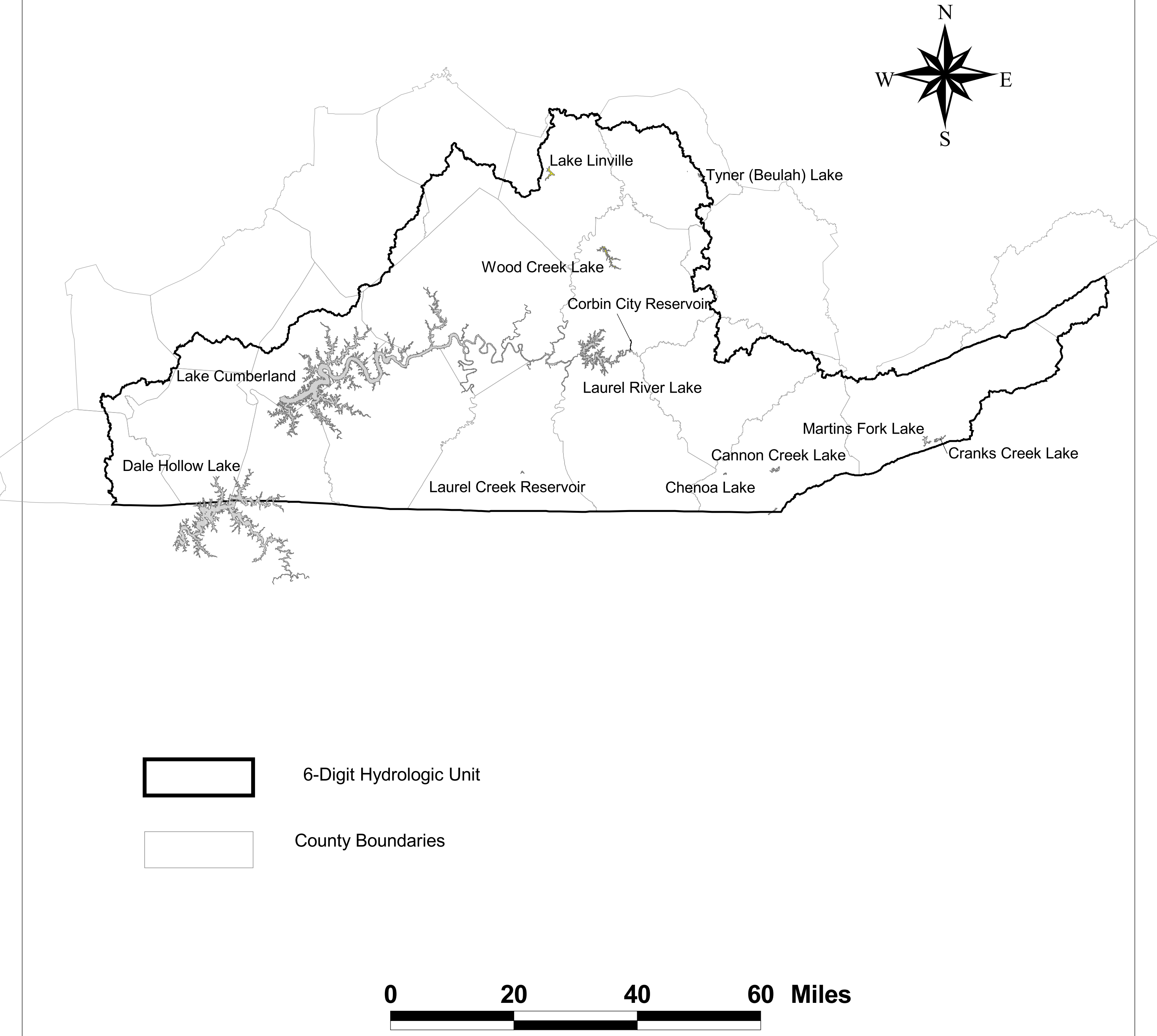


Figure 4-8. Monitoring Sites on Cumberland Lake and Dale Hollow Lake

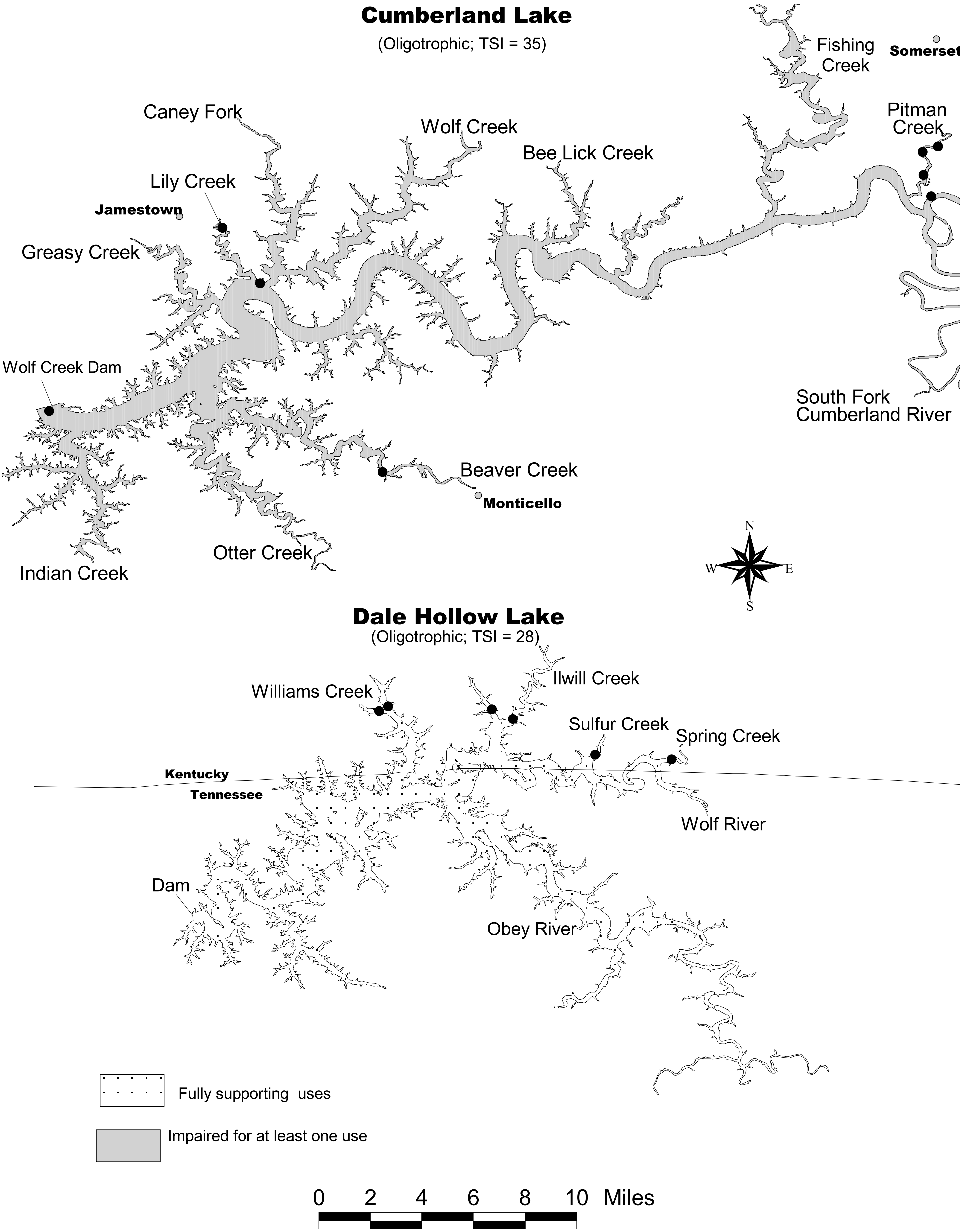


Figure 4-9. Monitoring Sites on Laurel River Lake and Wood Creek Lake

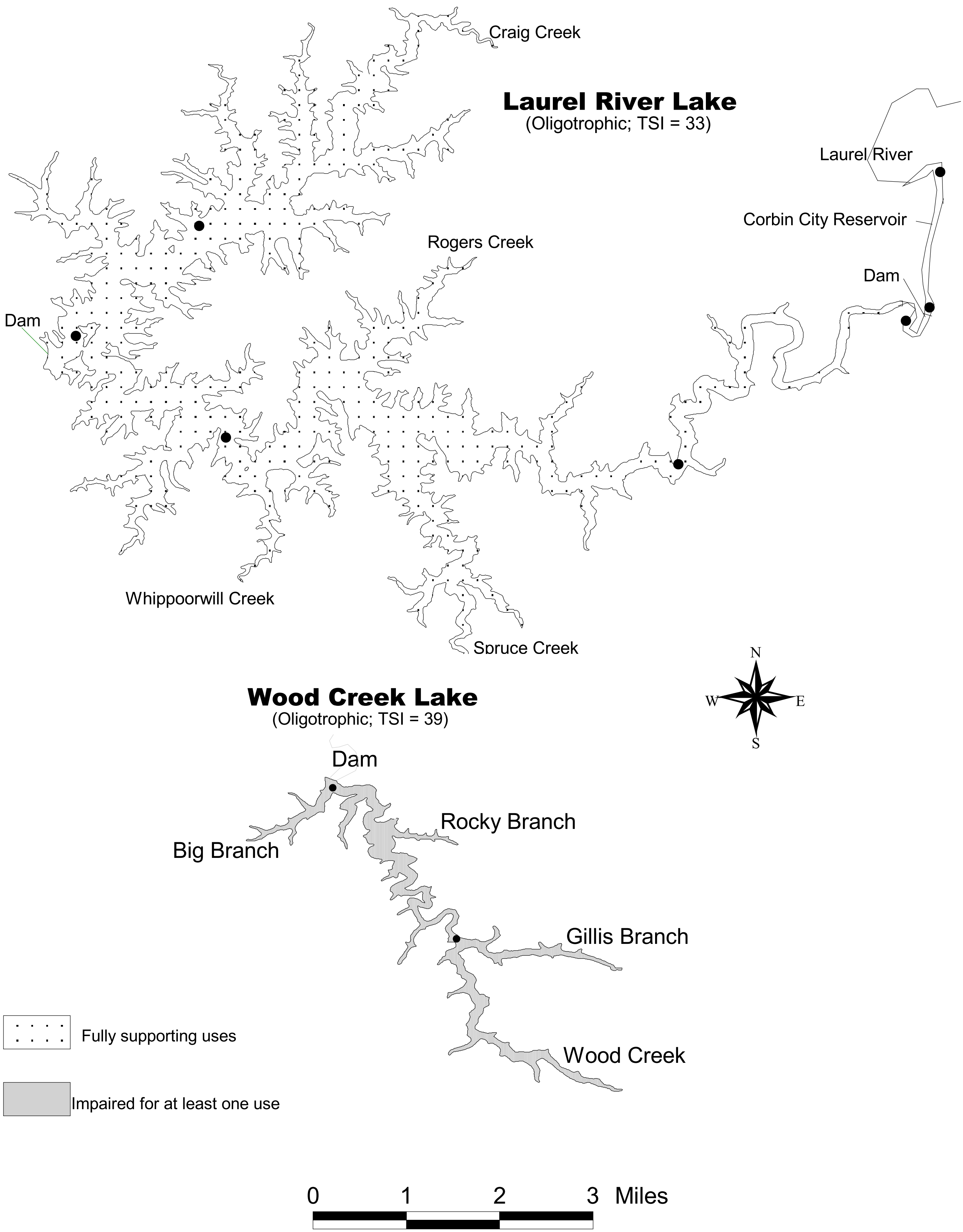


Figure 4-10. Monitoring Sites on Small Reservoirs in the Upper Cumberland River Basin

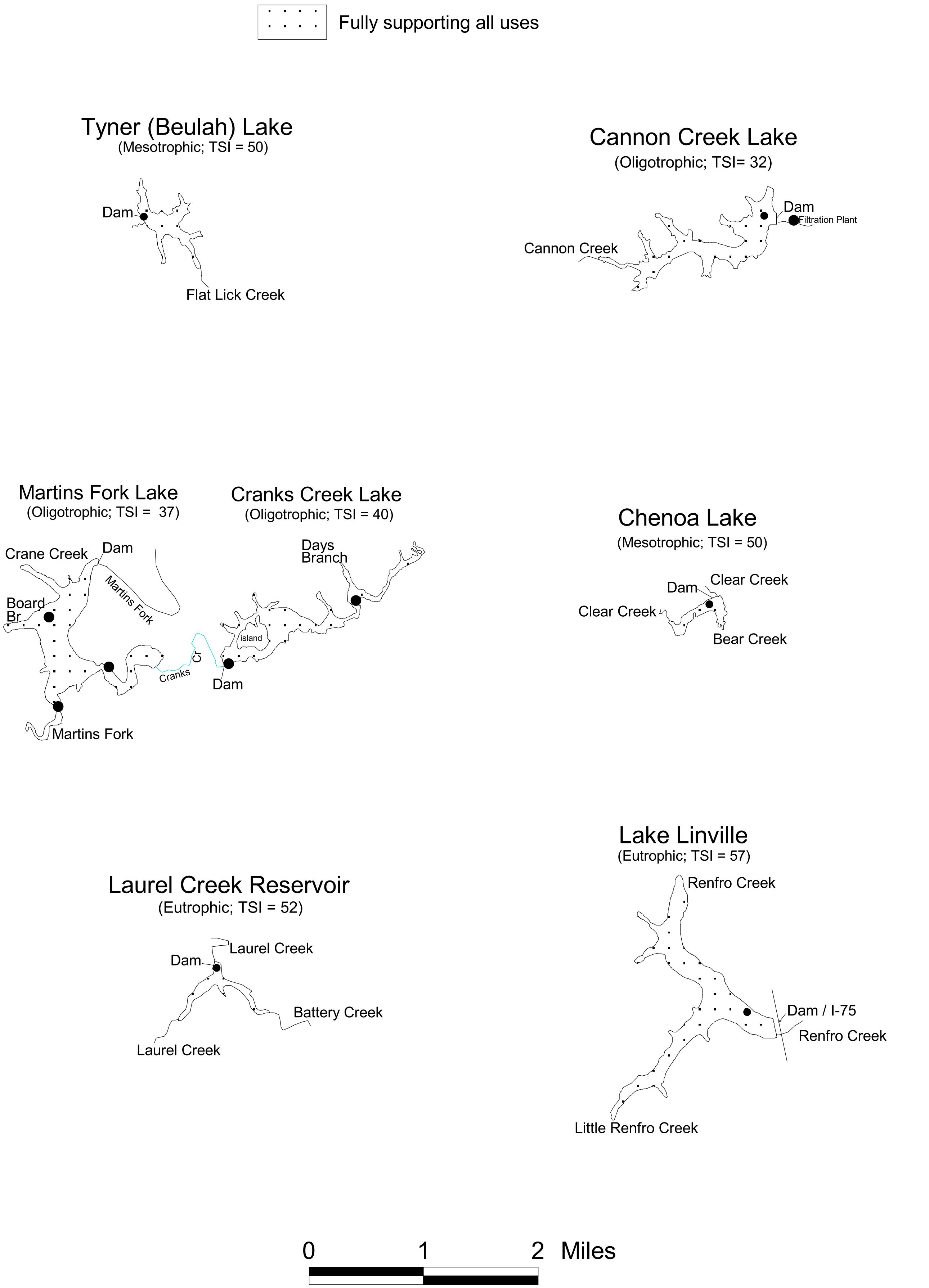
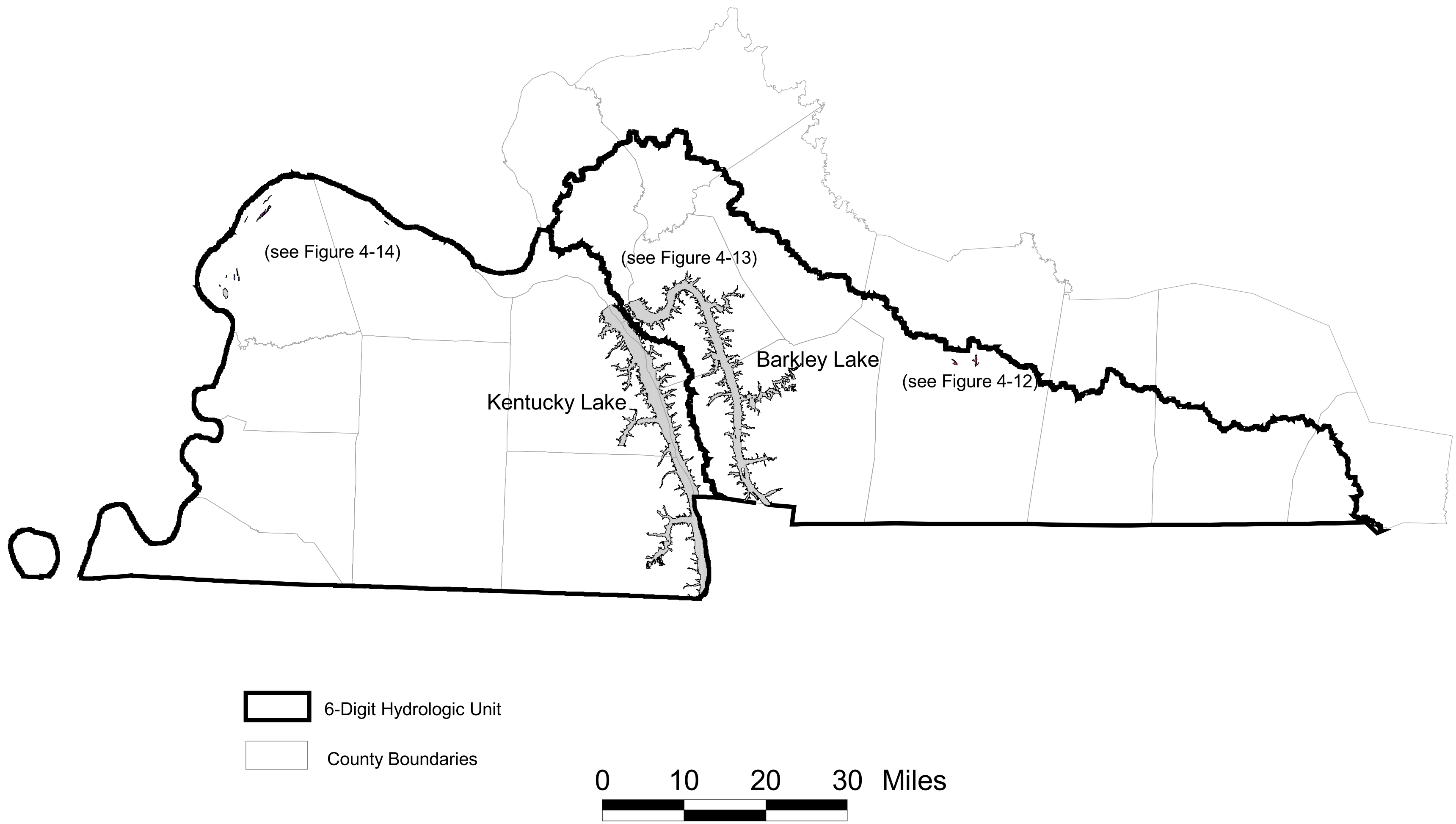
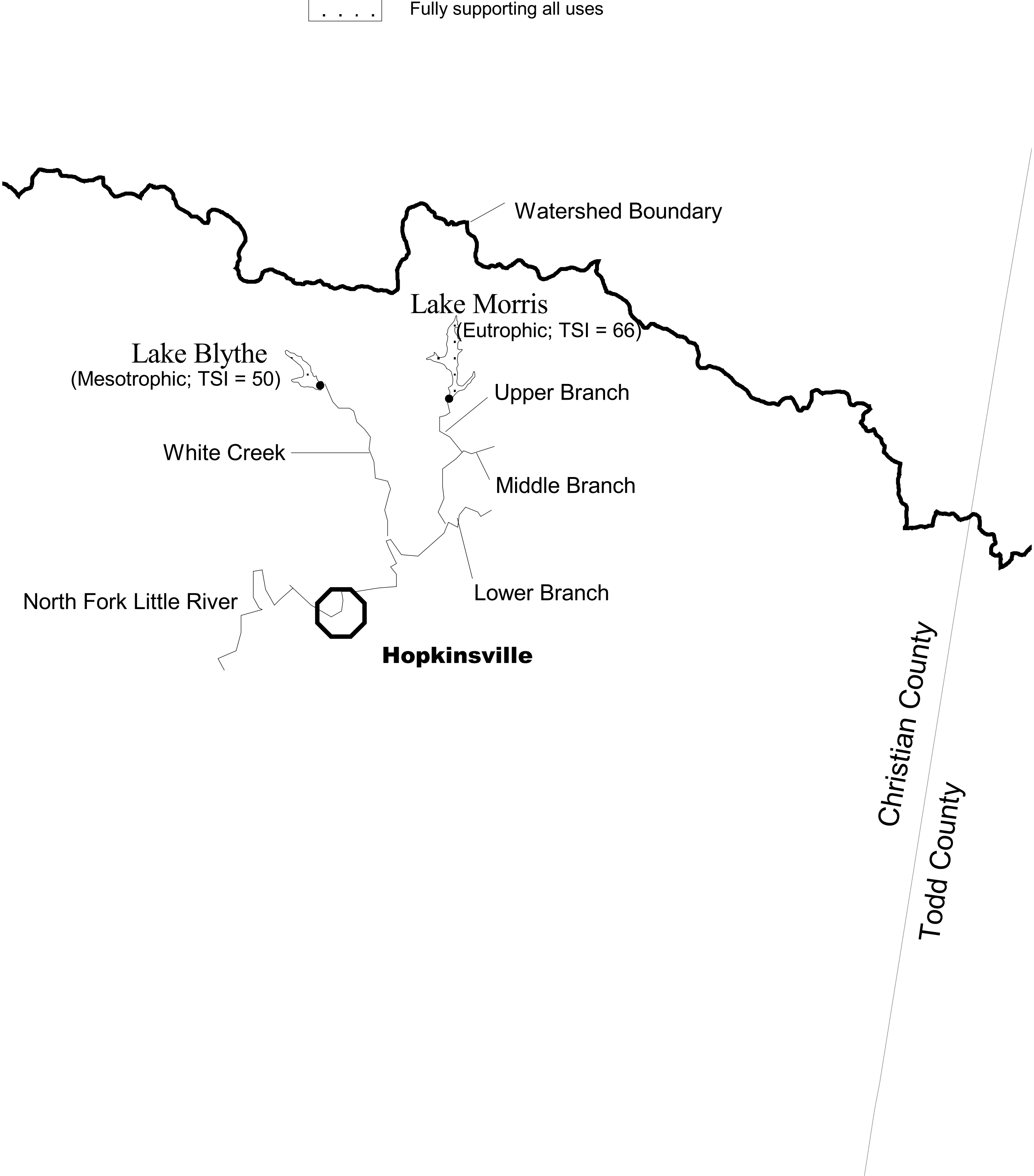
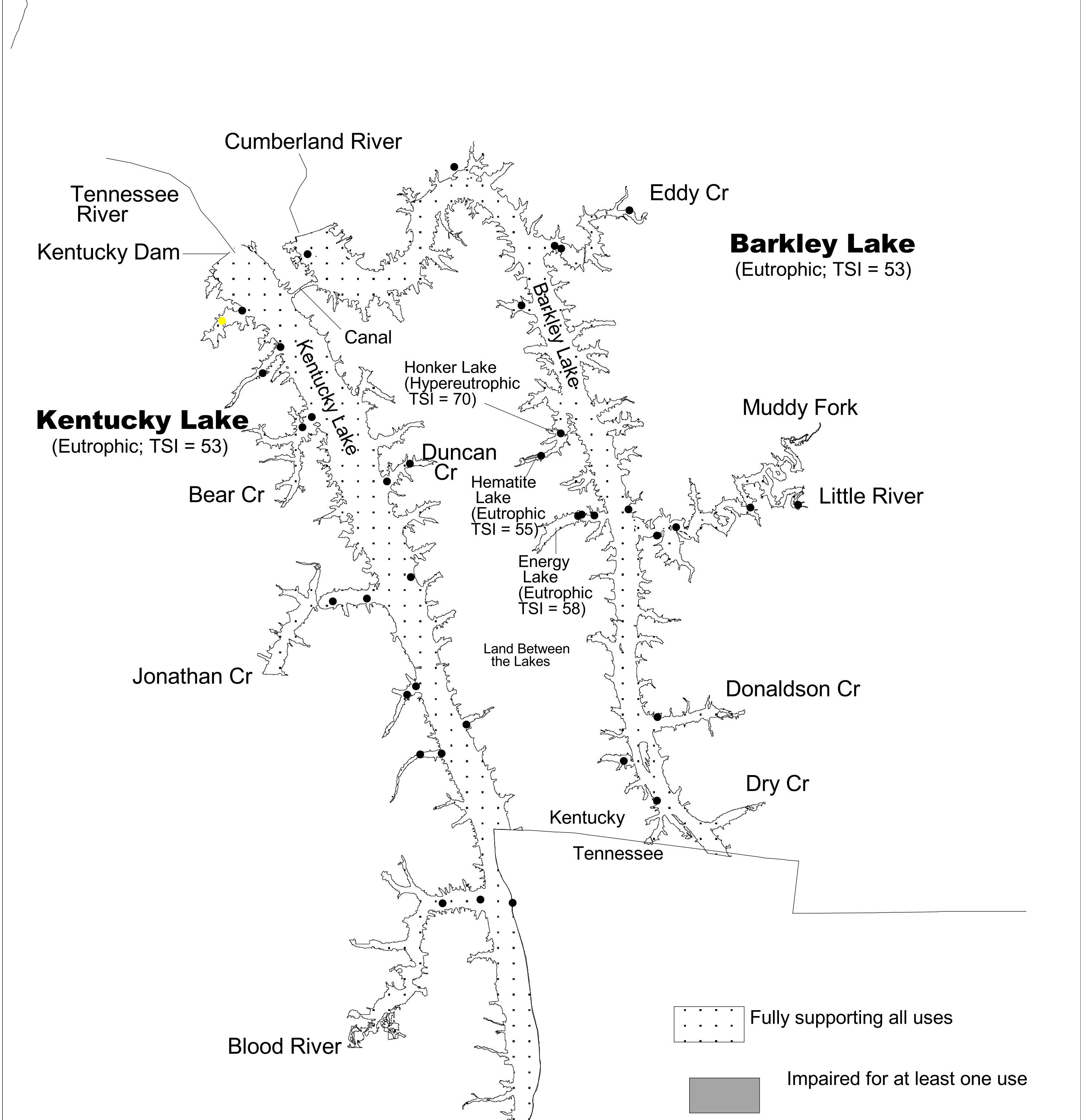


Figure 4-11. Lakes and Reservoirs Monitored in the Lower Cumberland, Tennessee, and Mississippi River Basins

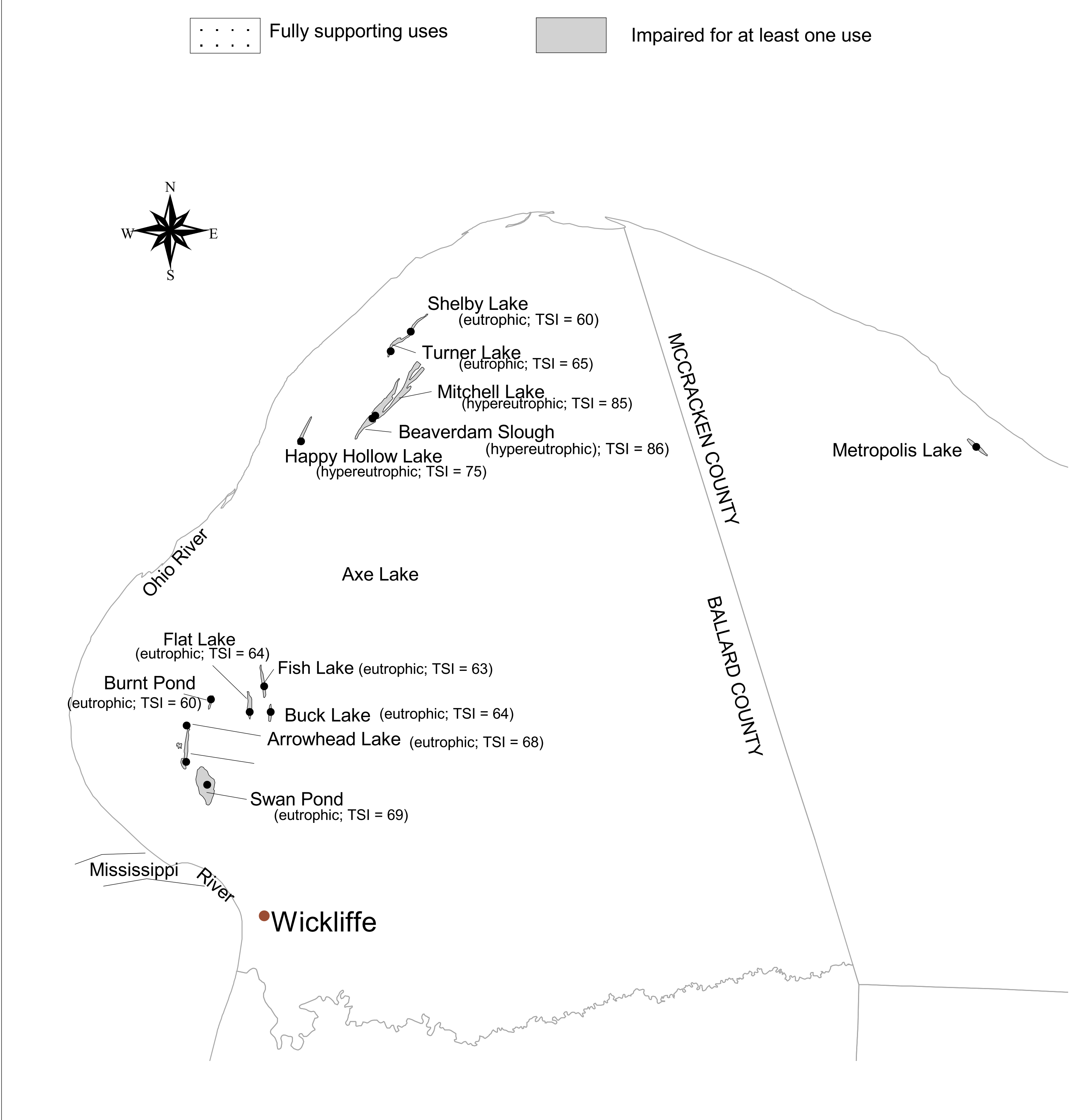




Fully supporting all uses
Watershed Boundary
Lake Morris
(Eutrophic; TSI = 66)
Lake Blythe
(Mesotrophic; TSI = 50)
Upper Branch
White Creek
Middle Branch
North Fork Little River
Lower Branch
Hopkinsville
Christian County
Todd County



Cumberland River
Tennessee River
Kentucky Dam
Eddy Cr
Barkley Lake
(Eutrophic; TSI = 53)
Canal
Kentucky Lake
Barkley Lake
Honker Lake
(Hypereutrophic
TSI = 70)
Muddy Fork
Kentucky Lake
(Eutrophic; TSI = 53)
Duncan Cr
Hematite Lake
(Eutrophic
TSI = 55)
Little River
Bear Cr
Energy Lake
(Eutrophic
TSI = 58)
Land Between the Lakes
Jonathan Cr
Donaldson Cr
Dry Cr
Kentucky
Tennessee
Blood River
Fully supporting all uses
Impaired for at least one use



Fully supporting uses
Impaired for at least one use
N
W
E
S
Shelby Lake
(eutrophic; TSI = 60)
Turner Lake
(eutrophic; TSI = 65)
Mitchell Lake
(hypereutrophic; TSI = 85)
Beaverdam Slough
(hypereutrophic); TSI = 86)
Happy Hollow Lake
(hypereutrophic; TSI = 75)
MCCRACKEN COUNTY
BALLARD COUNTY
Metropolis Lake
Ohio River
Axe Lake
Flat Lake
(eutrophic; TSI = 64)
Fish Lake (eutrophic; TSI = 63)
Burnt Pond
(eutrophic; TSI = 60)
Buck Lake (eutrophic; TSI = 64)
Arrowhead Lake (eutrophic; TSI = 68)
Swan Pond
(eutrophic; TSI = 69)
Mississippi
River
Wickliffe

REFERENCES

Tennessee Valley Authority. 2000-2001. Personal communications with the Kentucky Division of Water.

U.S. Army Corps of Engineers. 2001. Personal communication, Nashville Division with the Kentucky Division of Water.

White, D., K. Johnston, and G. Rice. Water Quality Assessment of Lake Barkley and Selected Tributary Embayments. Center for Reservoir Research, Murray State University, Murray, Kentucky.

Chapter 5. Groundwater

5.1 Introduction

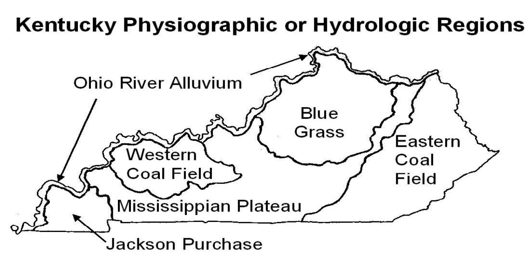
Current census data and estimates indicate 94.3 percent of Kentuckians receive their drinking water from a public water system or a well or a spring source that meets both primary and secondary drinking water standards for potable water (Table 5-1). The estimated numbers of well and spring sources that meet both primary and secondary standards for potable water were based on percentages of water wells and springs in the Department for Environmental Protection Consolidated Groundwater Database meeting those standards. Groundwater also provides water for industrial processes and irrigation and is a significant source for stream flow. Protection of this resource is crucial to Kentucky's economy, public health, and the environment.

Table 5-1. Census and Well Use Data[a,b,c]

Physiographic Region	Population on Wells[d]	Percent total Population
Bluegrass	45,760	2.5
Mississippian Plateau	134,620	20.6
Eastern Coalfield	276,333	43.9
Western Coalfield	30,592	10.1
Jackson Purchase	49,657	26.4
Statewide	505,254	13.7

[a]Total population 1990 Census: 3,685,296
[b]Total population 2000 Census: 4,041,769
[c]Water Supply Source: 1990 Census Data
[d]Extrapolation of 1990 census data to 2000 census data

5.2 Availability and Use



Naturally occurring potable groundwater is found throughout Kentucky, although quantities available for use vary considerably according to local geologic characteristics. Kentucky's groundwater resources exist in three aquifer types: granular aquifers that include continental deposits and river alluviums, karst aquifers that are dominated by rapid conduit flow, and fractured bedrock aquifers. High-yielding granular aquifers are typical of the Ohio River and Mississippi River valley that comprises the state's northern and western boundaries and in the continental (coastal plain) sediments of the Jackson Purchase Region. Granular aquifers generally provide adequate water for domestic, public, and industrial uses. Karst aquifers, developed in soluble rocks (e.g. limestone), occur under about 50 percent of Kentucky and are characterized by numerous shallow conduit-flow systems of generally limited extent. The most extensive karst aquifers are located in the Pennyroyal Region. Though usually less well developed, they also occur in the Inner Bluegrass Region. The karst aquifers generally provide sufficient water for domestic use, and some large karst springs supply municipal public water systems. In the Western and Eastern Coalfield regions, wells bored into fractured sedimentary rocks, primarily sandstones, shales, and siltstones, generally provide sufficient water for domestic use.

Approximately 500,000 persons depend on groundwater from wells and springs to supply individual households (Table 5-2). This number has remained stable because population growth has been offset by water line expansion. Households that depend upon private water wells for their drinking water are most numerous in eastern Kentucky and in the Jackson Purchase; these two regions account for more than 65 percent of all new well construction in the state (DOW groundwater database).

5.3 Groundwater Quality

In Kentucky, the quality of groundwater used by households for private domestic supplies appears to be generally good, although there are regions of the state where specific local problems exist. The principal, naturally occurring groundwater problems are microorganisms, nitrate, iron, sulfur, and high levels of dissolved solids ("salty" or "hard" water). Of these contaminants, the presence of nitrates and microorganisms in drinking water can represent serious potential health risks if consumed above maximum contaminant levels (MCLs) for an extended period of time or by persons vulnerable to infection or other health impacts (e.g. young children, the elderly, immuno-compromised people). On the other hand, iron, sulfur, and salt reflect more upon the aesthetic quality of water. In other words, water with relatively high levels of iron, sulfur, or salt may be unpleasant to use but not necessarily unhealthy. Assessing "potability" of water supplies therefore has two facets: (1) the issue of health concerns associated with specific contaminants and (2) the aesthetic water quality, in terms not only of taste, color, and odor but the effects upon clothing, fixtures and appliances, and household plumbing. Major sources of groundwater contamination in Kentucky are listed in Table 5-3.

Table 5-2. Estimates of Water Supply Sources for 1990 and 2000

	2000	Percent of State Population 2000	Percent Population on Potable Water Sources in 2000[a]	1990	Percent of State Population 1990	Percent Population on Potable Water Sources in 1990[a]
Service Connections	958,150	N/A	N/A	1,214,664	N/A	N/A
Population Served	3,512,049[b]	86.89	86.89	2,970,717	80.61	80.61
Population not served by a Community PWS[e]	529,720	13.11	7.21[d]	714,578	19.30	10.66[d]
Population on private Wells	374,547	9.27	5.23[d]	505,254	13.71	7.75[d]
Population on private springs and other sources	155,173	3.84	2.17[d]	209,324	5.68	3.21[d]
Total	4,041,769[c]	100.00	94.29	3,685,296	100.00	91.57

[a] Potable traditionally means water which poses no appreciable health risk (via pathogens or chemicals) for consumption. The assumption in this model is that all public water is "potable"; however, some public water systems do have occasional problems with Maximum Contaminant Levels (MCL) violations. Also, some public water systems fail secondary (non-enforceable) standards relating to taste and odor. These failures to meet secondary standards can be related to variations in source water quality and problems with treatment or the distribution system. Problems with public water systems (PWS) meeting secondary standards can be ongoing, but are more commonly occasional or intermittent. The Division of Water works with these systems to address secondary standard violations in order to bring these PWSs into compliance. For wells, springs, and other sources, other aesthetic considerations such as color, taste, and odor were considered in addition to pathogen or other contaminant issues in resolving the estimate of the number of people with access to potable drinking water sources.

[b] The population served by Community Public Water Systems is calculated by multiplying the total number of service connections by 2.6. N x 2.6 = PS, where N = the number of service connections, and PS = the estimated population served. The multiplier (2.6) represents the average number of people served per service connection.

[c] Number available from U.S. Census Bureau 2000.

[d] Based on Departmental studies, approximately 43.5% of all wells tested exceed the secondary standard for Iron. These studies tested pre-treatment water only and this number does not include water that is successfully treated via domestic treatment systems to meet or exceed primary and secondary standards. As the secondary standard for iron was the most common "potability" problem for private sources, we determined that this consideration would be the most conservative estimator of access to potable private sources. Please note that a well, spring, or cistern may have one or more conditions that affect the potability of the water.

[e] Population not served by a Community PWS includes those who depend on private wells, springs, cisterns, and hauled or bottled water.
Definitions: 1) "Community Public Water Systems" are public water systems serving an average of ≥ 25 people/day year-round or systems with ≥ 15 service connections; **2)** "Service connections" are individual homes and businesses connected to Community Public Water Systems; **3)** "Other sources" are springs, cisterns, and hauled water; and **4)** "Potable water" is water produced by any Community Public Water System and domestic and private water supplies which meets both the Primary Maximum Contaminant Levels and the Secondary Maximum Contaminant Levels.

Table 5-3. Major Sources of Groundwater Contamination

Contamination Source	Ten Highest Priority Sources	Factors Considered in Selecting a Contaminant Source[a]	Contaminants[b]
Agricultural Activities			
Agriculture Chemical Facilities			
Animal Feedlots	✔	I, III, V, VII	B, E, J, K, L
Drainage Wells			
Fertilizer Applications	✔	I, III, IV, V, VI, VII	E
Irrigation Practices			
Pesticides Applications	✔	I, III, IV, VI, VII	A, B
On-farm Agricultural Mixing and Loading Procedures			
Land Application of Manure (unregulated)			
Storage and Treatment Activities			
Land Application			
Material Stockpiles			
Storage Tanks (above ground)			
Storage Tanks (underground)	✔	I, III, IV, V, VI, VII	C, D, H
Surface Impoundment			
Waste Piles			
Waste Tailings			
Disposal Activities			
Deep Injection Wells			
Landfills	✔	I, III, IV, V, VI, VII	A, B, C, D, E, F, G, H, I, J, K, L, M (Leachate Compounds)
Septic Systems	✔	I, II, III, IV, V, VI, VII	A, B, C, D, E, F, G, H, J, K, L
Other			
Hazardous Waste Generators			
Hazardous Waste Sites			
Industrial Facilities	✔	I, III, IV, V, VII	A, B, C, D, E, F, G, H, I, J, K, L, M (TCE)
Material Transfer Operations			
Mining and Mine Drainage	✔	I, III, IV, V, VI, VII	G, H, M (Sediment and siltation runoff)
Pipelines and Sewer Lines			
Salt Storage and Road Salting			
Salt Water Intrusion			
Spills	✔	I, II, III, IV, V, VII	A, B, C, D, E, F, G, H, I, J, K, L, M (TCE)
Transportation of Materials			
Urban Runoff	✔	I, II, III, IV, V, VI, VII	A, B, C, D, E, F, G, H, J, L, M (Sediment)
Small-Scale Manufacturing and Repair Shops			

[a] **Factors**

I- Human health and/or environmental risk (toxicity)
II- Size of the population at risk
III- Location of the sources relative to drinking water sources
IV- Number and size of contaminant source
V- Hydrogeologic sensitivity
VI- State findings, other findings
VII- Best professional judgment

[b] **Contaminants**

A- Inorganic pesticides
B- Organic pesticides
C- Halogenated compounds
D- Petroleum compounds
E- Nitrate
F- Fluoride
G- Salinity / Brine
H- Metals
I- Radionuclides
J- Bacteria
K- Protozoa
L- Viruses
M- Other

In order to assess groundwater quality, several sources were used. These include: 1) well drillers' logs submitted to the DOW; 2) groundwater quality data collected from the DOW's ambient groundwater monitoring program and the inter-agency groundwater monitoring network; 3) groundwater quality data collected by DOW from Section 319(h) river basin studies; 4) sample data collected through various programs by the Kentucky Geological Survey (KGS); and 5) data derived from several smaller, local studies. A summary of the results of analysis of major parameters of concern in Kentucky is presented in Tables 5-4, 5-5 and 5-6. Water quality trends can be related to regional geology, land use, groundwater sensitivity, and well construction. Impacts on groundwater quality from human activities occur predominantly in the most sensitive (karst) areas and result primarily from agricultural activities. Persistent localized groundwater contamination from human activities occurs around older landfills, leaking underground storage tanks, poorly maintained septic systems and straight pipes, mining operations and drainage, and urban runoff. Less persistent, but still of concern locally, are spills and contamination from industrial facilities.

Table 5-4. Parameters of Interest: Summary

			SITES					SAMPLES				
Suite	Constituent	MCL (mg/L)	Number of Sites	Detects	Detects < ½ MCL	Detects >= ½ MCL	Detects > MCL	Number of Samples	Non-Detects	Detects < ½ MCL	Detects >= ½ MCL	Detects > MCL
OTHER	Fluoride		155	155	155	2	0	338	11	323	4	0
	Nitrate (as N)		184	171	143	39	7	387	37	118	232	7
	Nitrite (as N)		152	13	11	2	2	297	279	16	2	2
RCRA METALS	Arsenic	0.010	316	50	36	15	0	825	763	43	19	0
	Barium		316	315	310	8	3	825	1	811	13	5
	Cadmium		316	14	14	0	0	825	799	26	0	0
	Chromium		316	97	97	1	0	825	628	196	1	0
	Copper[a]	1.0	316	243	243	0	0	825	367	458	0	0
	Iron[a]		317	310	174	203	162	826	41	406	379	272
	Lead		319	60	50	15	9	828	757	56	15	9
	Manganese[a]		317	299	186	168	126	826	68	460	298	197
	Mercury		315	7	7	1	1	824	811	12	1	1
	Nickel[b]		316	135	134	1	1	825	585	239	1	1
	Selenium		315	11	11	0	0	824	805	19	0	0
	Silver[a,b]		314	54	54	0	0	804	744	60	0	0
	Zinc[a]		316	203	201	5	1	825	454	366	5	1
PCB	Aroclor 1016	0.0005	240	0	0	0	0	704	704	0	0	0
	Aroclor 1221	0.0005	240	0	0	0	0	704	704	0	0	0
	Aroclor 1232	0.0005	240	0	0	0	0	704	704	0	0	0
	Aroclor 1242	0.0005	240	0	0	0	0	704	704	0	0	0
	Aroclor 1248	0.0005	240	0	0	0	0	704	704	0	0	0
	Aroclor 1254	0.0005	240	0	0	0	0	704	704	0	0	0
	Aroclor 1260	0.0005	240	1	1	0	0	704	703	1	0	0
	Aroclor 1262	0.0005	240	0	0	0	0	704	704	0	0	0
	Aroclor 1268	0.0005	240	0	0	0	0	703	703	0	0	0
PESTICIDES	Acetochlor[c]		229	12	12	0	0	693	676	17	0	0
	Alachlor		229	5	5	0	0	693	677	16	0	0
	Atrazine		229	55	55	5	0	693	506	182	5	0
	Atrazine desethyl		229	57	57	0	0	693	482	211	0	0
	Cyanazine[b]		229	0	0	0	0	693	693	0	0	0
	Metalochlor[b]		229	28	28	0	0	692	596	96	0	0
	Simazine		229	28	28	4	3	693	639	49	5	3

Table 5-4 (Cont'd)

			SITES					SAMPLES				
Suite	Constituent	MCL (mg/L)	Number of Sites	Detects	Detects < ½ MCL	Detects >= ½ MCL	Detects > MCL	Number of Samples	Non-Detects	Detects < ½ MCL	Detects >= ½ MCL	Detects > MCL
SOC	Anthracene[c]	0.830	93	5	5	0	0	117	112	5	0	0
	Benzo[a]anthracene[c]		93	5	0	5	5	117	112	0	5	5
	Benzo[a]pyrene		94	6	2	5	3	119	112	2	5	3
	Fluorene[c]	0.110	92	4	4	0	0	116	112	4	0	0
	Naphthalene[b]		410	13	11	2	2	947	930	15	2	2
VOC	Benzene		374	17	7	11	10	889	866	8	15	13
	Chlorobenzene[c]		374	1	1	0	0	889	888	1	0	0
	Dichloromethane (Methylene chloride)		374	16	10	6	2	889	873	10	6	2
	Ethylbenzene		374	12	10	2	1	889	874	13	2	0
	Methyl-tert-butyl ether (MTBE)[c]		374	39	30	10	9	888	817	56	15	14
	Tetrachloroethane (1,1,1,2-)[b]		374	0	0	0	0	889	889	0	0	0
	Tetrachloroethene[c]	0.010	374	18	16	2	2	889	840	47	2	2
	Toluene		374	18	16	2	2	889	865	22	2	2
	Trichloroethane (1,1,1-)		374	6	5	1	1	889	868	20	1	1
	Trichloroethene		374	9	3	8	8	889	853	3	33	30
	Vinyl chloride		374	3	1	2	2	889	886	1	2	2
	Xylene (1,2-)		374	13	13	0	0	889	868	21	0	0
	Xylene (1,3- & 1,4-)		374	18	17	1	0	889	865	23	1	0

[a] Secondary Drinking Water Regulation
[b] Health Advisory Level
[c] DEP standard
(These standards used where MCL unavailable)

Table 5-5. Parameters of Interest: Summary of Public Water Supply Sites

			PWS SITES					SAMPLES				
Suite	Constituent	MCL (mg/L)	Number Of Sites	Detects	Detects < ½ MCL	Detects >= ½ MCL	Detects > MCL	Number Of Samples	Non-Detects	Detects < ½ MCL	Detects >= ½ MCL	Detects > MCL
OTHER	Fluoride		14	14	14	0	0	36	0	36	0	0
	Nitrate (as N)		14	13	12	2	0	34	8	19	7	0
	Nitrite (as N)		14	0	0	0	0	27	27	0	0	0
RCRA METALS	Arsenic	0.010	44	6	5	2	0	156	148	5	3	0
	Barium		51	51	51	1	0	156	0	155	1	0
	Cadmium		44	3	3	0	0	156	151	5	0	0
	Chromium		44	11	11	0	0	156	107	49	0	0
	Copper[a]	1.0	44	39	39	0	0	156	57	99	0	0
	Iron[a]		44	41	28	24	20	156	20	71	65	46
	Lead		44	10	10	2	1	156	142	12	2	1
	Manganese[a]		44	39	27	22	17	156	17	83	56	31
	Mercury		44	1	1	1	1	156	153	2	1	1
	Nickel[b]		44	17	17	0	0	156	118	38	0	0
	Selenium		44	2	2	0	0	156	152	4	0	0
	Silver[a,b]		44	9	9	0	0	150	141	9	0	0
	Zinc[a]		44	24	24	1	0	156	101	54	1	0
PCBs	Aroclor 1016	0.0005	43	0	0	0	0	151	151	0	0	0
	Aroclor 1221	0.0005	43	0	0	0	0	151	151	0	0	0
	Aroclor 1232	0.0005	43	0	0	0	0	151	151	0	0	0
	Aroclor 1242	0.0005	43	0	0	0	0	151	151	0	0	0
	Aroclor 1248	0.0005	43	0	0	0	0	151	151	0	0	0
	Aroclor 1254	0.0005	43	0	0	0	0	151	151	0	0	0
	Aroclor 1260	0.0005	43	0	0	0	0	151	151	0	0	0
	Aroclor 1262	0.0005	43	0	0	0	0	151	151	0	0	0
	Aroclor 1268	0.0005	43	0	0	0	0	151	151	0	0	0
PESTICIDES	Acetochlor[c]		43	1	1	0	0	151	150	1	0	0
	Alachlor		43	0	0	0	0	151	151	0	0	0
	Atrazine		43	8	8	2	0	151	109	40	2	0
	Atrazine desethyl		43	8	8	0	0	151	102	49	0	0
	Cyanazine[b]		43	0	0	0	0	151	151	0	0	0
	Metalochlor[b]		43	6	6	0	0	150	127	23	0	0
	Simazine		43	4	4	2	1	151	143	6	2	1

Table 5-5. (Cont'd)

Suite	Constituent	MCL (mg/L)	PWS SITES: Number of Sites	Detects	Detects < ½ MCL	Detects >= ½ MCL	Detects > MCL	SAMPLES: Number Of Samples	Non-Detects	Detects < ½ MCL	Detects >= ½ MCL	Detects > MCL
SOC	Anthracene[c]	0.830	2	1	1	0	0	2	1	1	0	0
	Benzo[a]anthracene[c]		2	1	0	1	1	2	1	0	0	1
	Benzo[a]pyrene		2	1	0	1	0	2	1	0	1	0
	Fluorene[c]	0.110	1	0	0	0	0	1	1	0	0	0
	Naphthalene[b]		88	1	1	0	0	216	215	1	0	0
VOC	Benzene		88	2	1	1	0	216	214	1	1	0
	Chlorobenzene[c]		88	0	0	0	0	216	216	0	0	0
	Dichloromethane (Methylene chloride)		88	7	4	3	1	216	209	4	3	1
	Ethylbenzene		88	1	1	0	0	216	215	1	0	0
	Methyl-tert-butyl ether (MTBE)[c]		88	8	7	2	1	216	205	9	2	1
	Tetrachloroethane (1,1,1,2-)[b]		88	0	0	0	0	216	216	0	0	0
	Tetrachloroethene[c]	0.010	88	6	6	0	0	216	195	21	0	0
	Toluene		88	2	2	0	0	216	214	2	0	0
	Trichloroethane (1,1,1-)		88	1	1	0	0	216	211	5	0	0
	Trichloroethene		88	2	0	2	2	216	214	0	2	2
	Vinyl chloride		88	0	0	0	0	216	216	0	0	0
	Xylene (1,2-)		88	1	1	0	0	216	215	1	0	0
	Xylene (1,3- & 1,4-)		88	3	3	0	0	216	213	3	0	0

[a] Secondary Drinking Water Regulation
[b] Health Advisory Level
[c] DEP standard
(These standards used where MCL unavailable)

Table 5-6. Finished Drinking Water Data on Groundwater Sources and Groundwater Under the Direct Influence of Surface Water, 2000 - 2001

Sites	Parameter Group	Total Number of Analyses	Non-Detects	Detects Less than MCL	Greater than MCL
153	VOC	10,574	10,467	66	6
138	SOC	10,001	9,929	64	8
126	IOC	2,765	2,407	330	3
247	NO_3	781	197	582[a]	2

[a] 83 of these values greater than 5 mg/l

5.3.1 Coliform Bacteria Data from Drillers' Logs

For any well built to supply potable water, according to 401 KAR 6:310, water well drillers are required to collect a water sample for coliform bacteria analysis. A report from the laboratory must be enclosed when the well record is submitted to DOW. Coliform sample results are available from the period between 1986 to the present for 20,868 of the water wells represented in the DOW groundwater database (Table 5-7). Drillers' reports indicate that approximately 7 percent of new wells constructed exhibited contamination from coliform bacteria at the time of installation. This number may be slightly higher or lower due to the relative ease of sample contamination during collection and the possibility that the disinfection products in the well might not have been cleared before sample collection. Although a water well driller is required to disinfect a new well, state plumbing regulations do not require a plumber to disinfect a new home plumbing system that is connected to the same well. This fact contributes to the high bacterial contamination numbers reported by some county health departments.

Table 5-7. Data on Bacteria and Odor Problems with New Wells

Region	Bacterial	Odor (sulfur)	Totals
Eastern Coalfield	17,685	829	18,514 (6.7%)
Bluegrass	5,812	73	5,885 (7.6%)
Mississippian Plateau	13,597	1,211	14,808 (10.5%)
Western Coalfield	1,671		1,671 (12.7%)
Jackson Purchase	2,533		2,533 (5.3%)
Totals[a]	41,298 (7.7%)	2,113 (0.4%)	43,411 (8.1%)

[a] Actual totals should be slightly less because some households have wells with multiple problems

Shallow, hand-dug wells, wells in karst (limestone and cave areas) terrain, and wells with insufficient casing are subject to the influence of surface water and are susceptible to bacterial contamination. It is important to note that bacterial contamination of a well and the plumbing system can be effectively treated by inexpensive and regular disinfection of the well and plumbing system.

5.3.2 Pesticides in Groundwater

Pesticides and herbicides are a significant groundwater quality concern in karst regions of Kentucky but are not routinely detected in other areas of the state. Herbicides are generally applied to row crops in the spring as a pre-emergent control for weed growth. Because precipitation, runoff, and infiltration also are high during that time of year, pesticides are detected more often in the spring.

Data collected from 1995 through 2000 indicate that atrazine (and its metabolites) and metolachlor are the most commonly detected herbicides. For example, 2,330 samples were analyzed for atrazine and 23 percent of samples (540) contained detectable atrazine levels, ranging from 0.001 - 5.26 μg/L. Metalochlor detections were not as common. Of 1,896 samples analyzed, 12.9 percent (245 samples) had detectable levels of metalochlor, ranging from 0.002 - 9.456 μg/L. The great majority of samples analyzed that contained detectable levels of atrazine and metalochlor were collected in karst springs and wells located in karst terrain.

Throughout Kentucky, sensitivity of the aquifer to impact from surface activities, which is largely a function of the groundwater flow regime and land use, appear to be the primary factors controlling the occurrence of pesticides. Results indicate that pesticide levels are generally highest and occur more frequently in karst areas, where anisotropic, turbulent flow through solution cavities and conduits predominates. These karst areas are generally coincident with areas of high row-crop production and pesticide use, especially in the Mississippian Plateau physiographic province of west-central and western Kentucky and are highly susceptible to impacts from surface activities. Elsewhere, in wells and non-karst springs, pesticide detections have been uncommon. Of particular note is that no pesticides were detected in the Eastern Kentucky Coal Field physiographic province, an area of slower, fracture-flow groundwater movement and of very limited row-crop production.

5.3.3 Nitrate in Groundwater

Nitrate-nitrogen has a Maximum Contaminant Level (MCL) of 10 mg/l. According to KGS data, there is a significant correlation between well depth and the concentration of nitrate-nitrogen. Ten percent of the relatively shallow hand-dug wells exceeded the MCL for nitrate-nitrogen, with significantly lower concentrations for drilled wells, generally decreasing with well depth. For all wells (0–500-ft category), approximately 4.5 percent exceeded the MCL. Approximately 3 percent of sampled springs (31 out of 1,018) exceeded the MCL for nitrate-nitrogen. Common sources of nitrate in water include plant and animal matter, human and animal waste, household septic systems, and fertilizers. Because it dissolves readily in water, nitrate from these sources is usually present at least in low concentrations in drinking-water supplies, regardless of the water source. Public water suppliers test for concentrations of nitrate. This testing is much less common for private water supplies, however. More than 1,500,000 people in Kentucky use groundwater supplies, including approximately 1,200,000 people supplied through public water systems and more than 500,000 using private wells or springs. Excess nitrate in drinking water has been found to cause methemoglobinemia, or Blue Baby Syndrome, in infants less than 6 months old (Kross and others 1992; Bruning-Fann and Kaneene 1993). EPA has established an MCL for nitrate in public drinking water because of health concerns. The MCL for nitrogen can be expressed as units of nitrate (NO_3 –) or as units of nitrogen (N), referred to as nitrate-nitrogen (nitrate-N or NO_3 -N). The MCL expressed as units of nitrate is 45 mg/L. The MCL expressed as units of nitrate-nitrogen is 10 mg/L (U.S. EPA 1994). Some laboratories use the term “parts per million” (ppm), which is essentially equivalent to mg/L in fresh water.

The time of year that samples are collected can affect the nitrate concentration detected. Some wells and springs have a greater concentration of nitrate from mid-December to mid-February. Some sites may also have a higher concentration within days or weeks of nearby use of fertilizers or application of manure. The physical and biological environment of a region affects the occurrence and movement of nitrate in groundwater and how quickly nitrate is reduced in the subsurface. Other factors can also have a local influence on contamination of groundwater. If a well is located near an inefficient septic system, nitrate may enter shallow groundwater at high concentrations. Frequent use of nitrate fertilizers or concentrated application of manure (animal feedlots, etc.) may also locally contaminate the groundwater. In addition, ineffective seals around well casings may allow unrestricted downward movement of contaminated shallow groundwater.

The MCL for nitrogen was exceeded in approximately 4.5 percent of all wells (0-500 ft deep). Ten percent of hand-dug wells (38 out of 391), 7 percent of wells from 0 to 50 ft deep (59 out of 842), 5 percent of wells from 51 to 100 ft deep (77 out of 1,506), 3 percent of wells from 101 to 150 ft deep (25 out of 737), and 1 percent of wells from 151 to 500 ft deep (7 out of 660) exceeded the MCL for nitrogen. Approximately 3 percent of sampled springs (31 out of 1,018) exceeded the MCL. These data show that the likelihood of well contamination is highly dependent on well depth. Hand-dug wells are especially prone to contamination because they are recharged by very shallow groundwater, and shallow groundwater generally has higher concentrations of nitrate than deep groundwater.

5.3.4 Secondary Contaminants in Groundwater

Iron is present in significant quantities in many rock formations and soils throughout the state. Iron gives the soil its reddish color and can be seen in rock formations as yellow, orange, and green coloration. Iron has a secondary drinking water standard of 0.3 mg/l based on taste, color, and staining. Secondary drinking water standards are recommended (non-enforceable) standards for finished water produced by public water systems. Low-grade iron ore was mined and smelted throughout the state in the past.

Data from the departmental groundwater quality database, regional, and Section 319(h) studies indicate that iron may represent an aesthetic problem for a large proportion of private groundwater users. Where total iron (both dissolved and suspended components) was concerned, less than half of all groundwater sources tested exceeded the secondary (aesthetic) MCL of 0.3 mg/l.

A recent Department for Environmental Protection study indicated 30 percent of the wells and springs (81 domestic water supplies) tested during a 2000-2001 study along the North Fork of the Kentucky River exceeded the secondary standard for total iron. The North Fork study also tested some of the iron levels after treatment and found that the iron levels were well below the secondary iron standard in almost every case. Iron well water concentrations above 10 mg/l are being successfully treated by a variety of different methods. Colloidal organic iron from iron reducing bacteria is often a large contributor to high total iron concentrations. This colloidal organic iron can be controlled by following the routine water well disinfection routines in the Generic Groundwater Protection Plan for Domestic Water Wells (401 KAR 5:037).

For dissolved iron, one-fourth of groundwater sources tested exceeded the standard. In two 1988 Department for Environmental Protection studies, iron exceeded the secondary standard in more than 40 percent of samples from both the Gateway ADD (100 wells) and Calvert City (62 wells).

The Kentucky Consolidated Groundwater Database shows 43.5 percent of the samples collected exceed the non-enforceable secondary drinking water standard for iron (Table 5-8). It should be noted that most data collection projects such as the Groundwater Monitoring Network, pesticide monitoring, and Section 319(h) nonpoint source studies all collect "raw water" or water before any domestic treatment. The percentage of water at the tap exceeding the secondary drinking water standard is probably much lower because of commonly used domestic water treatment systems. Very little data has been collected where both the raw and treated water is tested to determine the effectiveness of the domestic water treatment systems in the state. Iron is, however, a problem that can be satisfactorily treated in private household systems.

Table 5-8. Total Iron Values (mg/l) from Private Wells[a]

	Bluegrass	Eastern Coalfield	Purchase	Ohio R Alluvium	Western Coalfield	Mississippian Plateau	State
Greater or Equal to 0.3 mg/l	19 (11.3%)	103 (63.6%)	21 (24.7%)	32 (32.3%)	19 (35.2%)	37 (36.3%)	231 (43.5%)
Less than 0.3 mg/l	10 (88.7%)	59 (36.4%)	64 (75.3%)	67 (67.7%)	35 (64.8%)	65 (63.7%)	300 (56.5%)
Total number of samples	29	162	85	99	54	102	531

[a] from the DEP Consolidated Groundwater Database

Sulfurous odor is a term that can mean several things. Hydrogen sulfide, the rotten egg smell gas, can come from leaking sour gas formations below, sulfide-reducing bacteria in the area around the well bore, or rotting of organic materials in the aquifer. Sulfurous odors on the hot water side of a plumbing system can be formed because of use of an inappropriate anode in the hot water heater for the type of source water. Also, sulfurous odors may be caused by the development of sulfur bacteria in the hot water heater. The lower water heater temperatures used to save energy and protect against scalds combined with the lack of routine well and plumbing system disinfection allow sulfur-reducing bacteria to flourish in modern water heaters. Raising the temperature above 170^o for a couple of weeks every so often or routine disinfection of the plumbing system can eliminate this problem.

Aquifers that have sulfurous odors can be inexpensively treated by chlorination followed by filtration or by aeration. Commonly, the sulfurous odors can be greatly reduced simply by following the Generic Groundwater Protection Plan for Domestic Water Wells (401 KAR 5:037) and routinely disinfecting the well. Wells that have sulfurous natural gas can be treated with aeration followed by degassing. Sulfurous odors are reported only in 0.4 percent of the new wells drilled in the state.

Total dissolved solids (TDS) indicates the amount of dissolved minerals present in water but does not differentiate between minerals. The secondary (non-enforceable) drinking water standard for TDS is 500 mg/l to prevent the undesirable effects of hardness, deposits, colored water, staining, and salty taste in water. The Kentucky Consolidated Groundwater Database data indicates 3.5 percent of the springs and 20.5 percent of the wells tested exceed the 500-mg/L TDS standard (Table 5-9). When this problem is caused by hardness minerals (calcium, magnesium, iron, and manganese), the problem can be easily treated with standard water softening equipment.

The type of dissolved mineral(s) that causes the higher TDS levels is fundamental to the effects of the high TDS and the ability to treat or use the water. Water with a high TDS that is caused by calcium may have some problems with scale deposits but still be considered good water for drinking purposes. Water with the same high TDS that is caused by salts may be considered undrinkable and whole-house treatment cost would be considered cost prohibitive. Many families use a small inexpensive reverse osmosis system to produce water for drinking and cooking while using the "salty" water for sanitary purposes. Many public systems also exceed the TDS standard which creates the market for the "water conditioning industry" to remove hardness minerals. Table 5-9 summarizes the Groundwater Quality Database results for TDS.

The USGS (1966) produced a map titled "Fresh-Saline Interface in Kentucky," which shows that waters with TDS concentrations greater than 1000 mg/l occur at depths as shallow as 100 feet in some deeper valleys of the state. Areas that had extensive pre-law oil and gas production also tend to have higher TDS levels in shallow groundwater.

Table 5-9. Total Dissolved Solids Data (mg/l) from the Groundwater Quality Database

Spring Data

	Bluegrass	Eastern Coalfield	Purchase	Ohio R Alluvium	Western Coalfield	Mississipian Plateau	State
Greater or Equal to 500 mg/l	28 (6.8%)	24 (14.3%)	0	0	0	1 (0.1%)	53 (3.5%)
Less than 500 mg/l	386 (93.2%)	144 (85.7%)	9 (100%)	8 (100%)	25 (100%)	877 (99.9%)	1449 (96.5%)
Total number of Samples	414	168	9	8	25	878	1502

Well Data

	Bluegrass	Eastern Coalfield	Purchase	Ohio R Alluvium	Western Coalfield	Mississippian Plateau	State
Greater or Equal to 500 mg/l	12 (48.0%)	30 (28.8%)	48 (48.0%)	26 (12.1%)	5 (5.1%)	13 (11.7%)	134 (20.5%)
Less than 500 mg/l	13 (52.0%)	74 (71.2%)	52 (52.0%)	189 (87.9%)	93 (94.9%)	98 (88.3%)	519 (79.5%)
Total number of Samples	25	104	100	215	98	111	653

Properly constructed modern water wells are a viable source of drinking water in the state. A domestic water supply well requires a homeowner to take responsibility for maintenance and treatment. Well owners who do not maintain a well or a treatment system often have problems. The cost associated with treating the most common well water problems is minimal and many times this is only the cost of a gallon of bleach and some time for a yearly water well disinfection.

Currently, federal legislation is being discussed that would provide low-interest loans and grants to private well owners to replace wells and domestic treatment systems. If this legislation is enacted, many low-income families would be able to abandon shallow hand-dug wells and replace them with modern, properly constructed wells with modern point-of-entry domestic treatment systems.

Another commonly used, but surrogate measure of water quality is the number of "contaminated" sites such as the number of landfills with groundwater contamination, and the number of "regulated" groundwater sites, such as underground injection control wells (Figure 5-10). Tracking the number of such sites can be a useful tool for measuring programmatic success, and though less so, an effective surrogate measure of groundwater quality changes. In order to be very useful, changes in the number of sites should be tracked over a number of reporting periods. However, it should be noted that simply evaluating the total number of sites does not provide a very accurate measure of either programmatic progress nor groundwater quality.

5.4 Groundwater Protection Programs

Kentucky has established or is maintaining many programs that protect the Commonwealth’s groundwater resources (Table 5-11). Three programs are highlighted in the following paragraphs.

5.4.1 Ambient Groundwater Monitoring Network

Since 1995, the DOW has sampled groundwater at approximately 240 sites as part of the state’s ambient groundwater monitoring program. Monitoring sites include public and private water supplies, unregulated public access springs (i.e., "roadside springs"), and unused springs. Approximately 70 sites are sampled from one to six times per year, depending on the type of aquifer. Water quality parameters include nutrients, major inorganic ions (e.g., carbonate, sulfate, iron and manganese, chloride, sodium, calcium, and magnesium), metals, volatile and semi-volatile organics, and pesticides. Each year the Division of Water also conducts quarterly sampling at 30 additional sites on a watershed basis as part of an ongoing watershed initiative Section 319(h) cooperative effort. In addition, the DOW conducts quarterly groundwater monitoring at four sites under an agreement with the Division of Pesticides.

Table 5- 10. Groundwater Contaminated Sites Summary, 2000 - 2001

Source Type[a]	Number of Sites		Sites with Confirmed Releases	Sites with Groundwater Contamination	Contaminants[b]	Source
NPL	19		19	19	PCBs, SVOCs, VOCs, Metals, Inorganics, Pesticides, and Radionuclides	Division of Waste Management (DWM) Superfund Branch State Superfund Section
State Sites[c] CERCLIS	1911		1271	111		
Non-UST Petroleum	984		899	46	Petroleum	
UST	4,731		2,827	810	BTEX, PAH, Lead	DWM - UST Branch
RCRA Corrective Action	91	**RCRA-D 32**	32	32	Organic Compounds	DWM - Solid Waste Branch
		RCRA-C 59	35	35	Pesticides, Cyanide, PCBs, VOCs, ABNs, PAHs, Metals, and Radionuclides	DWM – Hazardous Waste Branch
DOD/DOE	6		6	6		
UIC	Total 4365	**Class I 1** **Class II 3788** **Class V 3000**	N/A	N/A	Varied	EPA

[a]Source Type:

NPL - National Priority List
DOD - Department of Defense
DOE - Department of Energy
RCRA - Resource Conservation and Recovery Act
UIC - Underground Injection Control
UST - Underground Storage Tank
CERCLIS - Comprehensive Environmental Response, Compensation, and Liability Information System

[b]Contaminants:

PCB - Polychlorinated Biphenyl
SVOC - Semi Volatile Organic Compound
VOC - Volatile Organic Compound
BTEX - Benzene, Toluene, Ethylene, and Xylene
PAH - Poly Aromatic Hydrocarbons
ABN - Acid Base Neutral

[c]This number includes approximately 600 sites from CERCLIS that EPA has investigated. Approximately 500 of these sites have been closed by EPA and referred to Kentucky's State Superfund Program

5.4.2 Wellhead Protection Program

Kentucky's Wellhead Protection Program requires public water systems that rely on groundwater to develop a wellhead protection plan (WHP) for their source water. A WHP is designed to identify the recharge area of the well(s) or spring(s), identify the potential contaminant sources in the recharge area, and implement groundwater protection strategies for these areas. Wellhead protection is an integral part of Kentucky's Source Water Assessment Program (SWAP). Kentucky has been a national leader on source water protection; it was the first state in the nation to have its SWAP approved by the U.S. Environmental Protection Agency. All groundwater-dependent public water systems will have completed their wellhead protection plans by March 2003. Currently, approximately 500,000 Kentuckians are being served by public water systems in various phases of wellhead protection.

5.4.3 Groundwater Protection Plan Program

Kentucky's Groundwater Protection Plan (GPP) regulation requires entities conducting activities that have potential to pollute groundwater to develop and implement a groundwater protection plan. The GPP includes pollution prevention measures such as preventive maintenance, best management practices, spill response plans, accurate record keeping, and personnel training. Regular inspections ensure that the protective practices are in place and functioning properly. The Groundwater Branch has been focusing implementation of this broad program in wellhead protection areas and in areas where problems or threats are known (see Table 5-11).

Kentucky also has a program that requires all agriculture and silviculture operations to develop and implement best management practices in accordance with Kentucky's Agriculture Water Quality Act to prevent pollution of the waters of the Commonwealth. All agriculture and silviculture producers were required to have an Agriculture Water Quality Plan in place by October 2001. Implementation of this program is ongoing, and resources, including cost-share funds, are being focused at addressing problems, particularly in priority watersheds.

Table 5-11. Groundwater Protection Programs[a,b]

Programs or Activities	Implementation Status	Responsible State Agency
Active SARA Title III Program	✔ Continuing Efforts	Department for Environmental Protection Commissioner's Office
Ambient Groundwater Monitoring System	✔ **Continuing Efforts**	**Division of Water**
Aquifer Vulnerability Assessment	N/A	N/A
Aquifer Mapping	✔ Ongoing	Kentucky Geological Survey/Division of Water
Aquifer Characterization	✔ Ongoing	Kentucky Geological Survey/Division of Water
Comprehensive Data Management System	✔ Established	Division of Water
EPA-endorsed Core Comprehensive State Ground-Water Protection Program (CSGWPP)	N/A	N/A
Groundwater Discharge Permits	✔ Continuing Efforts	Division of Water
Groundwater Best Management Practices	✔ Established	Division of Conservation
Groundwater Legislation	✔ Implemented	Division of Water/Kentucky Geological Survey
Groundwater Classification	N/A	N/A
Groundwater Protection Program	✔ **Established**	**Division of Water**
Groundwater Quality Standards	✔ Developing	Division of Water
Groundwater Sensitivity Mapping	✔ Complete	Division of Water
Interagency Coordination for Groundwater Protection Initiatives	✔ Established	Interagency Technical Advisory Committee
Non-Point Source Controls	✔ Established	Division of Water
Pesticides State Management Plans	✔ Developing	Division of Pesticides
Pollution Prevention Program	✔ Implementing	Division of Water
Resource Conservation and Recovery Act (RCRA) Primacy	✔ Established	Division of Waste Management
Source Water Assessment Program	✔ Continuing Efforts	Division of Water
State Superfund	✔ Established	Division of Waste Management
State RCRA Program Incorporating more Stringent Requirements than RCRA Primacy	N/A	N/A
State Septic System Regulations	✔ Established/Developing new Standards	Cabinet of Health Services
Underground Storage Tank Installation Requirements	✔ Established	Division of Waste Management
Underground Storage Tank Remediation Fund	✔ Established	PSTEAF
Underground Storage Tank Permit Program	✔ Continuing Efforts	Division of Waste Management
Underground Injection Control Program	✔ Fully Established	EPA Region IV
Vulnerability Assessment for Drinking Water/Wellhead Protection	✔ Completed	Division of Water
Well Abandonment Regulations	✔ Continuing Efforts	Division of Water
Wellhead Protection Program (EPA-approved)	✔ **Established**	**Division of Water**
Well Installation Regulations	✔ Continuing Efforts	Division of Water

[a]Shaded programs are N/A (Not Applicable) at this time
[b]Bold-faced programs are elaborated on the preceding pages